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ABSTRACT

This student assignment book is designed for use in a course on print reading as applied to the machine shop course. Introductory materials include a student progress record, a list of references, and a pretest. For each of eight lessons, information sheets with one or more assignment sheets and a test are provided. The lessons cover the role of technical drawing in society; conventional lines; multi-view drawing or orthographic projection; abbreviations, dimensions, notes, and symbols in reading a print; sectional views; auxiliary views; orthographic sketching; and pictorial sketching. Additional assignment sheets are provided that relate to special machining operations, such as gears, assemblies, and hole patterns. A glossary is appended. (YLB)

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ASSIGNMENT BOOK
IN
PRINT READING
FOR MACHINE SHOP

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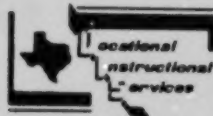
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PREFACE

Since the beginning of time civilization has been confronted with the problem of communication. The expression of thoughts and ideas has taken many forms such as verbal languages, audio-visual media, art, and music. One of the most important advancements in communication has been through the development of technical drawing, the guidepost to industry.

Today the role of the machinist in our industrial society requires the ability to accurately read and interpret industrial prints. In addition, the ability of the machinist to convey an idea through freehand sketching is of significant value. To meet these requirements, the student must make every effort to prepare oneself in print reading, sketching, the terminologies used, and the various procedures used for giving information on the print. The intent of this book is to provide the information and assignments through which this can be accomplished.

HOW TO USE

The student assignment book, *Print Reading For Machine Shop*, consists of information sheets with one or more assignment sheets and a test for each lesson. In the appendix are a glossary of terms common to the machinist trade.

Additional assignment sheets relating to special machining operations, such as gears, assemblies, and hole patterns are provided in section II-D of the assignment book. These assignment sheets contain information sheets and may be assigned as the instructor desires. Extra sheets for sketching are also included to be used for additional problems or the student's selected project, as the instructor may assign.

Student assignments consist of drawing assignments selected to give the student an opportunity to learn and apply the principles of orthographic projection and pictorial presentation as well as other drafting practices; and to develop skill in making a simple drawing and applying dimensioning practices.

Print Reading assignments provide the student with the opportunity to read and interpret a print that is common to machine prints and make application of the basic principles of mathematics used daily in the shop.

For maximum benefit from this assignment book, the student is encouraged to read carefully the information sheet preceding each assignment; study the directions for each assignment; and complete the assignment to one's best ability.

Each student assignment book contains a record of assignment progress sheet so as to maintain a record of the assignment and date assigned and the completion date with the student's score. The method of scoring the student's work and length of time to complete the work is left to the discretion of the instructor.

**STUDENT PROGRESS RECORD
FOR
PRINT READING FOR METAL TRADES**

The Student Progress Record contains the title and number of each assignment and test. Space has been provided for:

1. Record of the date the assignment was made by instructor
2. Record of the completion date of each assignment
3. Record of grade or rating for each assignment or test

The student will keep a record of each assignment or test, thereby providing an accurate record of work assigned, completed, and grade achieved. This will give both student and instructor a record of the student's progress.

ASSIGNMENT NUMBER	SUBJECT OR TOPIC	Date Assigned	Date Completed	Grade/ Rating
II-A-1(AS)	History of Technical Drawing			
II-A-1(T)	Test			
II-B-1(AS)	Conventional Lines of Drawing			
II-B-1(T)	Test			
II-B-2(AS)	Multi-View-Missing Lines			
II-B-2a(AS)	Multi-View-Missing Lines			
II-B-2b(AS)	Multi-View-Three Views			
II-B-2c(AS)	Multi-View-Three Views			
II-B-2(T)	Test			
II-B-3(AS)	Dimensions, Notes and Symbols			
II-B-3(AS)	Abbreviations, Notes and Symbols			
II-B-3(T)	Test			
II-B-4(AS)	Identify and Complete Sectional Views			
II-B-4a(AS)	Print Reading - Sectional Views			
II-B-4b(AS)	Print Reading - Sectional Views			
II-B-4(T)	Test			
II-B-5(AS)	Print Reading - Auxillary Views			
II-B-5(T)	Test			
II-C-1(AS)	Sketch - Straight Lines			
II-C-1(AS)	Sketch - Curved Lines			

REFERENCES
FOR
ASSIGNMENTS SHEETS IN PRINT READING

The following reference books were used in the development of information sheets, assignment sheets, and tests for this assignment book. In the event the teacher or student feels that more information will be helpful, these books may be obtained to provide a supplemental reference.

1. Coover, Shriver L., Drawing and Blueprint Reading, McGraw-Hill Book Company, Dallas, Texas
2. Giesecke, Fredrick E., Mitchell, Alva, Spencer, Henry C., and Hill, Ivan L., Technical Drawing, Fifth Edition, The Macmillan Company, New York, New York
3. Hardman, William E., Blueprint Reading For Metalworking Trainees, Third Edition, National Tool, Die and Precision Machining Association, 9300 Livingston Road, Washington D.C. 20022
4. Ihne, Russel W. and Streeter, Walter E., Machine Trades Blueprint Reading, Sixth Edition, American Technical Society, Chicago, Illinois 60637
5. Olive, C. Thomas and Payne, Albert V., Basic Blueprint Reading For Machine Shop, Delmar Publishers, Inc., Albany, New York 12205
6. Spence, William P., Drafting Technology and Practice, Charles A. Bennett Co., Inc., Peoria, Illinois 61614

PRINT READING
PRE-TEST
MATCHING TEST

Name _____ Date _____

Directions: One statement from Column I is closely related with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number of Column I.

Example: B 1. Mounted on an aperture card

- A. Print
- B. Microfilm
- C. Ammonia

Column I	Column II
_____ 1. Represents invisible edges	A. Tolerance
_____ 2. Gives distance between two edges	B. FOA
_____ 3. Total indicator reading	C. 2B
_____ 4. Permissible variation in size	D. 2.756
_____ 5. Relationship of normal views with each other	E. CSK
_____ 6. Finish all over	F. C'Bore
_____ 7. Class of internal thread fit	G. Degrees
_____ 8. Countersink	H. Print
_____ 9. Locates hole center	I. ✓
_____ 10. Angle measurement	J. Parallel
_____ 11. Lower limit of $2.758 \pm .002$	K. Dimension line
_____ 12. Bolt circle	L. Center line
_____ 13. Enlarge end of hole cylindrically	M. Leader line
_____ 14. Duplication of an original	N. 2.760
_____ 15. Machined surface	O. Hidden line
	P. Perpendicular
	Q. BC
	R. TIR

ONE RIGHT ANSWER MULTIPLE CHOICE TEST

Directions: Each of the following statements is followed by four answers. Only one of these answers is correct. Read each statement carefully and select the correct answer. Place the letter of the answer selected in the corresponding blank space in the right hand column.

Example: 1. The reproduction of an original drawing is a/an: C

- | | |
|-----------------|----------------|
| a. sketch | c. print |
| b. work drawing | d. duplication |

1. The true shape and size of an object is provided in a/an: _____

- | | |
|-----------------------|----------------------|
| a. isometric drawing | c. assembly drawing |
| b. multi-view drawing | d. pictorial drawing |

2. The number of normal views of an object is: _____

- | | |
|---------|----------|
| a. six | c. three |
| b. four | d. two |

3. The views most frequently selected for a work drawing are: _____

- | | |
|-------------------------------|---------------------------|
| a. left side, right side, top | c. front, right side, top |
| b. front, top, bottom | d. front, left side, top |

4. Internal features are simplified by use of a/an: _____

- | | |
|-------------------|-------------------|
| a. auxiliary view | c. assembled view |
| b. pictorial view | d. sectioned view |

5. In the thread note 5/8-18-UNF-2A, the 18 represents: _____

- | | |
|-------------------|---------------------|
| a. size of thread | c. threads per inch |
| b. class fit | d. type of thread |

6. An enclosed informational area used to provide the name of the part and other supplemental information is the: _____

- | | |
|-------------------|----------------------|
| a. specifications | c. bill of materials |
| b. title box | d. heading |

7. Spotfacing is used to: _____

- | | |
|----------------------------------|---|
| a. provide clearance for wrench | c. provide recess for bolt |
| b. provide smooth overall finish | d. provide flat surface for nut or screw head |

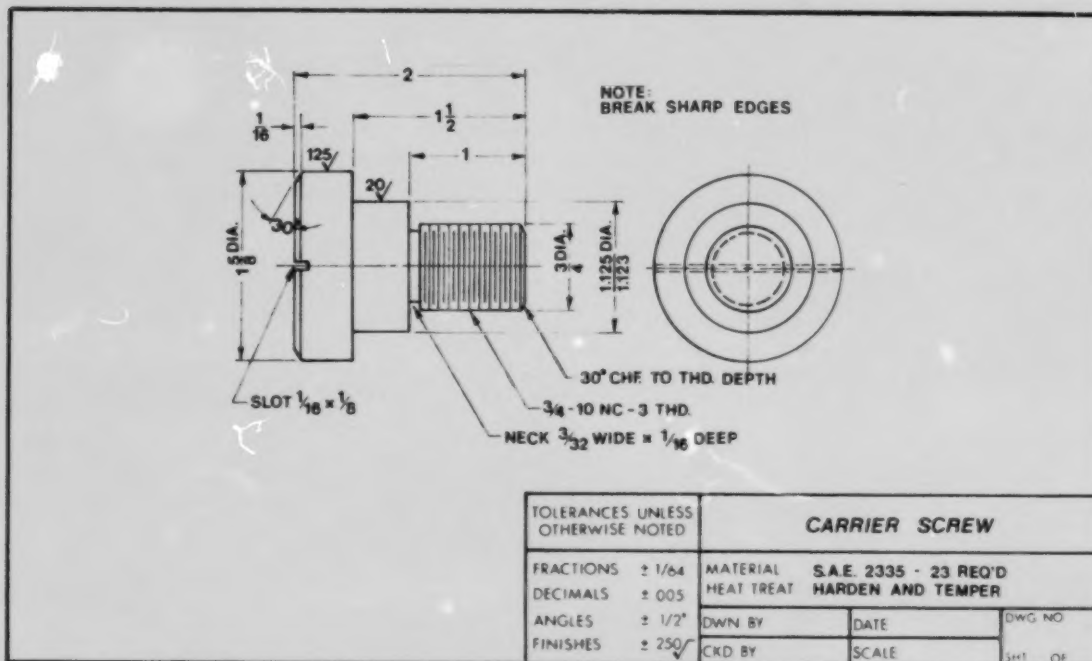
8. Auxiliary views are used to represent:
- a. hidden surfaces
 - b. slanted surfaces
 - c. assembled parts
 - d. gears
9. In the note $1/2"$ drill, $3/4"$ C'Bore = $3/8"$ deep, 2 holes, the counterbore hole depth is:
- a. $3/8"$
 - b. $1/2"$
 - c. $3/4"$
 - d. not given
10. A part with a given dimension of $6\ 3/4" \pm 1/64"$ would be acceptable if it measured between:
- a. $6\ 3/4" - 6\ 7/8"$
 - b. $6\ 21/64" - 6\ 25/64"$
 - c. $6\ 47/64" - 6\ 49/64"$
 - d. $6\ 23/32" - 6\ 25/64"$
11. A print that indicates correct position and proper location of parts in relation to each other:
- a. work drawing
 - b. detailed drawing
 - c. assembly drawing
 - d. sketch
12. Information that applies to a specific operation:
- a. local notes
 - b. general notes
 - c. specification
 - d. dimensions
13. Information that applies to an entire drawing:
- a. local news
 - b. general notes
 - c. specification
 - d. dimensions
14. The maximum size of a shaft whose dimension is $2.691" \pm .002"$:
- a. 2.689"
 - b. 2.6908"
 - c. 2.6912"
 - d. 2.693"
15. Reveals the interior of a part:
- a. auxiliary view
 - b. isometric sketch
 - c. sectioned view
 - d. oblique drawing

PICTORIAL RECALL TEST

Directions: Study the given print and complete each statement with the answer that will make the statement correct.

Example: 1. The order number for the part is ____.

82-124



- The name of the part is ____.
- The thread diameter is ____.
- The slot size is ____.
- A ____ finish is specified for the screw head.
- A total of ____ pieces are to be made.
- The maximum diameter of the screw head is ____.
- The minimum diameter of the shoulder is ____.
- A chamfer of ____ is cut to thread depth.
- A ____ finish is called for on the shoulder.
- The part is to be made from ____ material.
- The heat treatment process to be applied upon completion will be ____ and ____.
- The size of the thread relief is ____.
- The length of the shoulder is ____.

INFORMATION SHEET
ON
PRINT READING

II-A-1(IS)

SUBJECT: Drawing The Universal Graphic Language

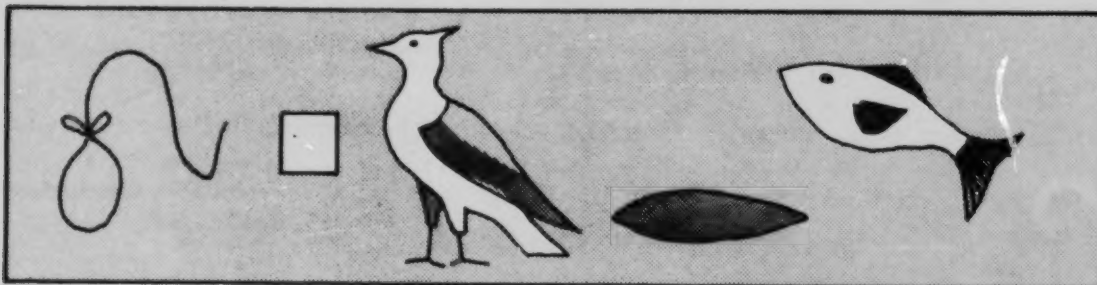
INTRODUCTORY
INFORMATION:

The term "universal graphic language" refers to the many ways technical information is communicated through the use of drawings or pictures. The word "universal" refers to the worldwide use of this graphic language that is common to all nations. The development and use of this graphic language parallels and complements the development of industry and our modern way of life.

GENERAL INFORMATION

Early History of Drawing

What type of communication was used in the early development of civilization? It is difficult for us to visualize a society without verbal communications, theaters, newspapers, books, and many other means of communication that are available to us today. If we were to turn back history some 35,000 years or more, we would find a form of written communication known as the Egyptian Hieroglyphics. It was a form of picture writing that portrayed characters, such as animals.



A much later evidence of the use of drawings can be found in the pyramids of Egypt, 3733 B.C., the Roman buildings and structures, not to exclude the most famous Circus Maximus of Rome, commonly referred to as the Roman Coliseum, or the Parthenon of Athens, Greece, 490 B.C. None of these structures could have been built without the assistance of a plan or drawing. As today, this required people who could draw the plan and people who could read the plan in order to carry out the task of seeing that the building was correctly built. Today, we have draftsmen and designers to make the drawings and skilled workers who read and interpret the drawing and manufacture the product.

As civilization progressed and industry developed, the development of the graphic language has kept pace with the increasing needs and demands of industry. Processes,

procedures, and methods are constantly changing, but the purpose and need for people to be able to read, interpret, and manufacture products as designed remains the same as some 3,000 years ago.

The Graphic Language

The term "graphic language" refers to the means of communicating through the use of pictures or drawings. Through many years of development, this graphic language has expanded to include many different methods of providing technical information through use of pictures. As an old Chinese proverb states, "One picture is worth one thousand words".

Modern technology requires many different types of drawings. Some of which are:

1. Design drawings for the manufacture and assembly of products
2. Architectural plans for the design of homes and commercial buildings
3. Production illustrations or pictorial drawings used to present technical information, such as assembled drawings or shaded drawings in a simple way.
4. Charts used to show technical data in a simplified way. Common uses are: production charts, safe work days, profit gains and losses
5. Maps, such as survey maps, road maps, and plant maps
6. Development drawings that are used in the sheetmetal industry for giving shape to flat material to be cut and formed

Regardless of the type or use of a drawing, its sole purpose is to provide complete and accurate information. In design drawings, such as those used in the machine shop, it is very essential that the drawing gives the following information accurately:

1. The true shape of the part
2. The exact size
3. Information concerning materials, production procedures, and specifications

In the manufacture of a new product, the design or print will travel to various departments before the product is completed. The various stages or departments involved are:

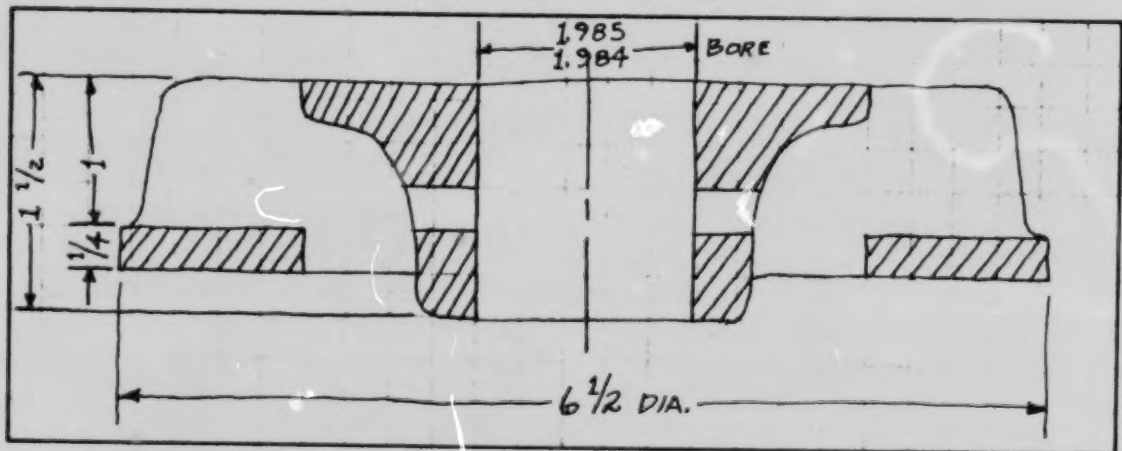
1. Design Department where the design begins in the form of an idea and sketch
2. Engineering Department for the study of economy, feasibility, usefulness, and efficiency
3. Materials Department where materials requirements and availability are determined
4. Tooling Department for the determination of required tooling and production procedures
5. Production Department where the production processes and regulations are controlled
6. Quality Control Department where the finished product is compared with the drawing to ascertain that all specifications and requirements are met

7. Assembly Department for the assembly of multi-part products according to the assembly drawing

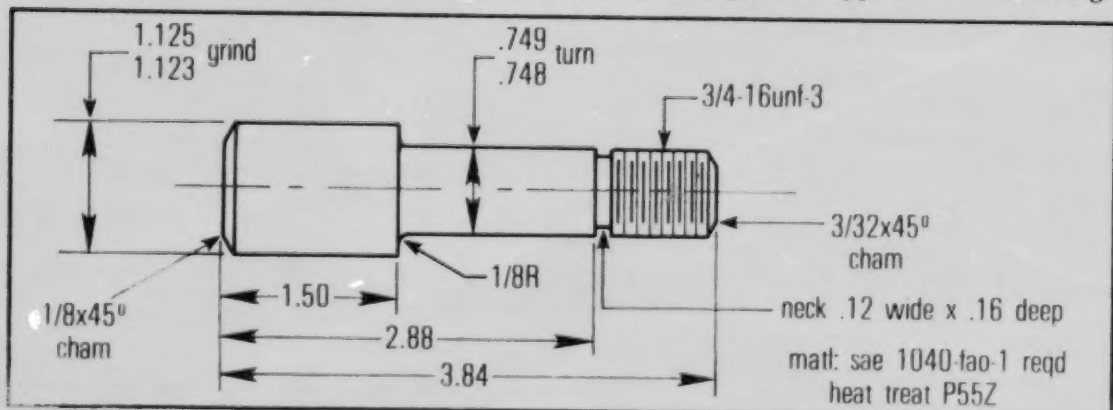
It is within these stages of development that the product is made or manufactured. The responsibility lies with the skilled machinist to take the drawing and produce the part to the specifications required. To do this requires not only skill in the operation of machine tools but proficiency in the reading and interpretation of the drawing or print.

There are various types of drawings used in industry today. The way the drawing is made is determined by the use of the drawing. Drawing representations common to the machinist trade include the following:

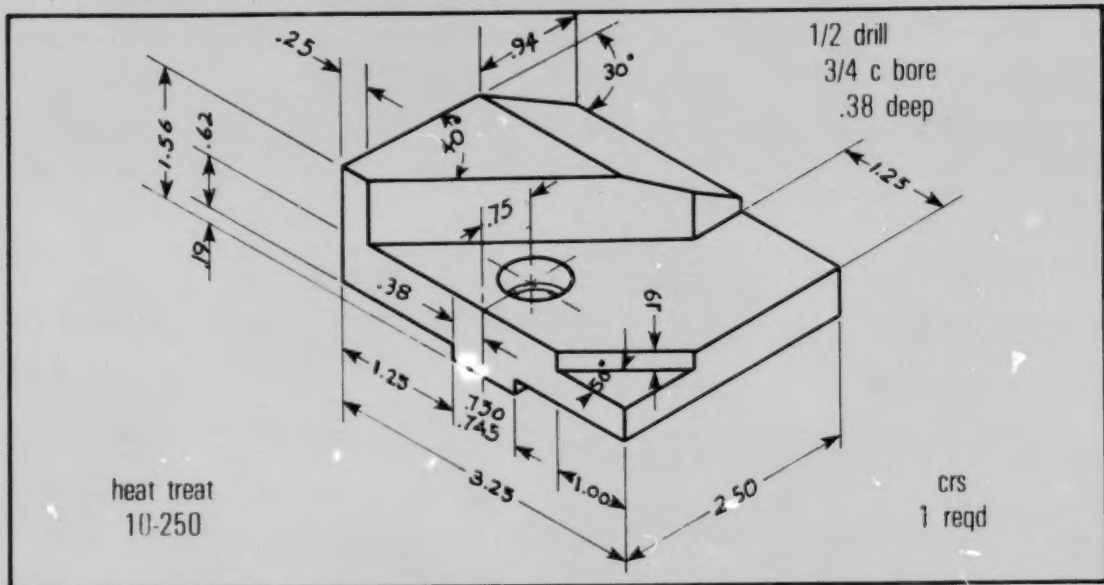
1. Rough sketch - This type of drawing is a freehand sketched drawing normally used to present an original idea from which the work drawing is made. In small machine shops, the machinist frequently uses this type of drawing to interpret the needs of a customer, as in Figure 1.



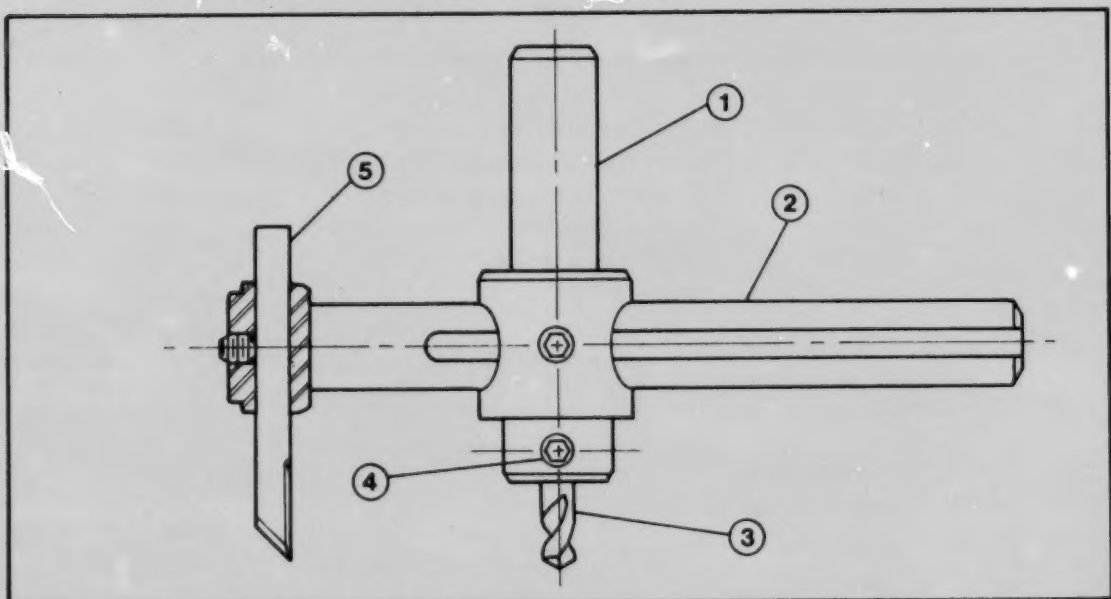
2. Work or Production drawings - Drawings of this type are the most commonly used since all information necessary to completely describe the size and shape of the part is given. Also notes and information concerning procedures and finish are given. Figure 2 shows an example of a typical work drawing.



3. Pictorial drawings - Frequently it is necessary to show the view of an object as one would see it in a photograph. A pictorial drawing is a three dimensional drawing that enables a non-technical person to visualize an object more easily. Pictorial drawings are also used as assembly drawings. Figure 3 is an example of the use of pictorial drawings.



4. Assembled drawings - In the assembly of multiple parts, it is necessary to show how the assembly is made. Frequently, the location of individual parts with respect to each other is important. In either situation the assembly drawing is used. Figure 4 shows the assembly of a circle cutter.



Drawing Reproductions

Considerable time and investment go into the planning and designing of an original drawing. Therefore, it is vital that the original be stored and filed properly to avoid loss or damage to it. Also, the need for more than one copy, as required due to the various manufacturing processes, does not make the redrawing of the original economically feasible.

To meet these needs a reproduction is made. The reproduction is called a "print", or as frequently referred to, a "blueprint". The term "blueprint", which is becoming obsolete, originated from the early process of reproduction whereby the print was on blue background and the drawing was white lines. Today most prints are made on white paper with blue or black ink lines. In future lessons the term "print" will be used instead of "blueprint".

The procedure for making a print consists of three main steps: These are as follows:

1. Making the original drawing on a transparent paper called tracing paper.
2. Taking a special treated sensitized paper and exposing the drawing and sensitized paper to light. The light exposes everything except where the lines or notes prevent penetration of the light.
3. Developing the sensitized paper by exposing it to either the liquid or fumes of a developing agent, such as ammonia. This causes the unexposed part to become visible, forming the print.

Prints are usually made on the same size paper as the original, although the paper may be cut to various sizes. Common sizes of prints are:

- | | |
|-----------------------|-----------------------|
| 1. Size A - 8½" x 11" | 4. Size D - 22" x 24" |
| 2. Size B - 11" x 17" | 5. Size E - 34" x 44" |
| 3. Size C - 17" x 22" | |

Today in many industries where security and storage are vital, microfilming is used. A microfilm is made of a part and is stored either on a roll of film or an aperture card. This permits it to be stored easily and pulled out when the need arises for making a change or to make prints.

ASSIGNMENT SHEET
ON
DRAWING - THE UNIVERSAL LANGUAGE

II-A-1(AS)

- SUBJECT:** History And Importance Of Technical Drawing
- AIM:** The student will be able to explain the importance of technical drawing in our industrialized society.
- INTRODUCTORY INFORMATION:** Graphic communication or language is a means of communication thousands of years old. The development of graphics has progressed greatly from the days of the Egyptians, some 35,000 years ago, to the present. Today, technical drawing, as it is referred to, is essential to our industrial society. Drawings are made in different ways and are used for many purposes. It may be an architectural plan for a home; a road map; production chart; a design drawing; or a freehand sketch of an idea or part. Regardless of how it is used, graphic communication is an important part in our way of life. In daily life people come in contact with many phases of graphic communication, such as assembling toys and appliances, construction work, the manufacturing business, and even the charts and x-rays which are read by doctors.
- REFERENCE:** Information Sheet II-A-1(IS) "Drawing - The Universal Graphic Language"
- QUESTIONS OR PROBLEMS:** The student will study carefully Information Sheet II-A-1(IS) "Drawing - The Universal Graphic Language" and complete the true and false questions and simple recall questions as directed.

ASSIGNMENT SHEET
ON
DRAWING - THE UNIVERSAL GRAPHIC LANGUAGE

II-A-1(AS)

NAME _____

DATE _____

DIRECTIONS: Read each of the following statements carefully. Some of the statements are true and some are false. Indicate the answer selected by a small circle around the T or F in the corresponding right-hand column.

- EXAMPLE:** 1. Drawing is vital to the manufacturing industry. ☒ T F
1. The term "universal graphic language" refers to a way of communicating with the use of pictures. T F
2. One of the first forms of graphic communication was the Egyptian Hieroglyphics. T F
3. The design drawing is important to the machinist because it gives all necessary information needed to manufacture the part. T F
4. By "universal" we mean that the use of drawings is confined to our country. T F
5. Charts are commonly used to show the amount of production that has been met in comparison with the goal set. T F
6. Multi-part products are assembled with the aid of assembly drawings. T F
7. Quality control refers to the amount of products that are manufactured in a given period. T F
8. Many products began as a sketch of someone's ideas. T F
9. It is unimportant for machinists to be skilled in the reading of prints. T F
10. A simple way of illustrating an idea is by the use of pictorial drawings. T F
11. Tracing paper is a transparent paper used in making original drawings. T F
12. A pictorial drawing shows three dimensions of an object in a single view. T F
13. Originally blueprints were made with blue lines on a white paper. T F

- | | | |
|--|---|---|
| 14. Work drawings provide all the information necessary to manufacture a part. | T | F |
| 15. Ammonia is used to develop the sensitized paper in making prints. | T | F |
| 16. It is more expensive to make a print than it is to make an original drawing. | T | F |
| 17. Transparent material will permit light to pass through. | T | F |
| 18. Diazo is a process of making a print. | T | F |
| 19. The machinist uses the original drawing when machining a part. | T | F |
| 20. The ability to sketch is not important to the machinist. | T | F |

SIMPLE RECALL QUESTIONS

II-A-1(AS)

DIRECTIONS: Read each statement carefully. Select a word or words which will complete the statement correctly. Place your answer in the blank space to the right of each statement.

EXAMPLE: 1. A form of communication portraying animal characters is known as the ____.

Egyptian Hieroglyphics

1. A design drawing gives the true size and ____ of an object.
2. ____ plans are used in the design and construction of homes and commercial buildings.
3. In the ____ department the finished product is checked against the drawing to ascertain all specifications have been met.
4. The machinist uses the ____ drawing in the machining of a part.
5. The planning and selection of tools for a job is the responsibility of the ____ department.
6. A reproduction of an original drawing is called a ____.
7. The need for storing a large number of drawings in a small space has brought about the use of the ____.
8. To make a print from an original requires a special ____ paper.
9. To assist non-technical or lay persons in visualizing an object, the ____ drawing is used.
10. A preliminary drawing that is drawn freehand is called a ____.

II-A-1(T)

DATE _____

EXAMPLE:

<u>B</u>	1. Completion of the temple of Amon	A. 30 B.C. B. 980 B.C. C. 1876 B.C.
----------	-------------------------------------	---

Column II

- 24

INFORMATION SHEET
ON
PRINT READING

II-B-1 (IS)

SUBJECT: The Alphabet of Lines

INTRODUCTORY
INFORMATION:

The line is the basis for all industrial drawings. By combining lines of different thickness or weight, length, and type, it is possible to accurately and graphically describe any object in such detail that a person skilled in the art of print reading can accurately visualize the shape of the part. Each line on a technical drawing has a definite meaning and is drawn in a certain way.

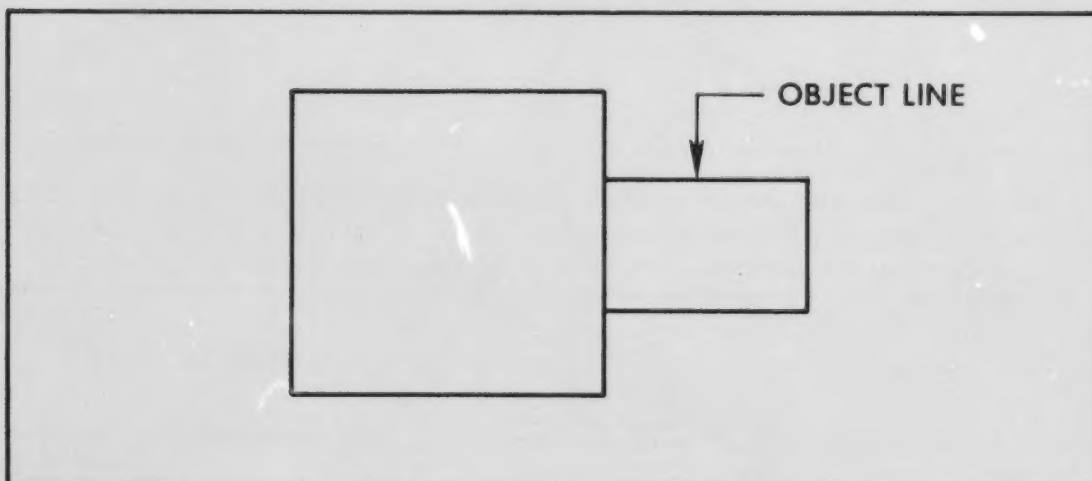
The American Standards Association has adopted these line conventions which are commonly referred to as the "Alphabet of Lines", and has recommended certain drafting techniques and standards for lines. The most commonly used lines from this alphabet include: (1) object lines, (2) hidden lines, (3) center lines, (4) dimension lines, (5) extension lines, (6) section lines, (7) cutting plane lines, (8) break lines, (9) leader lines, and (10) phantom lines.

A brief description of each line, with an example of each type, is given in the following information. The weights and sizes of the lines are relative because they depend on the size and complexity of the part drawn.

GENERAL INFORMATION

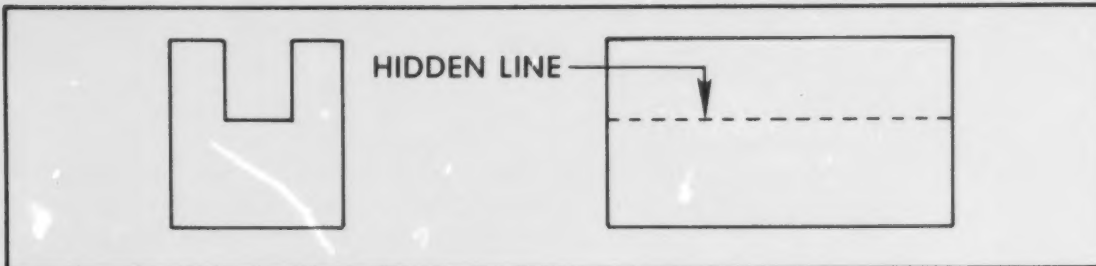
1. Object Line

A heavy solid line that is used to show or indicate all visible edges or surfaces of an object or any part of the object that is visible from any point of observation.



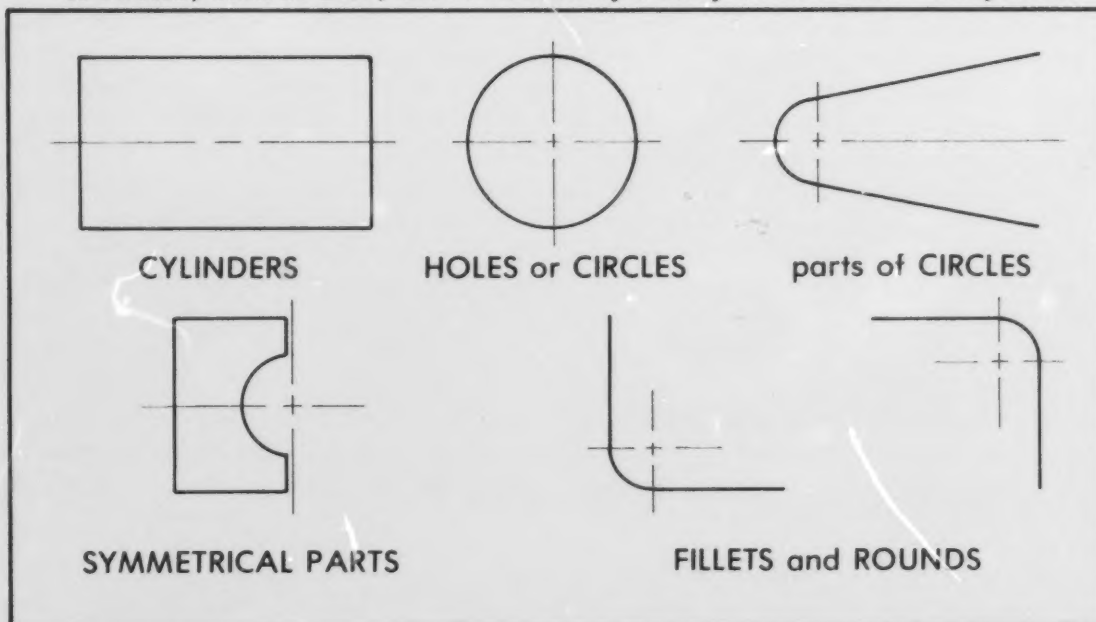
2. Hidden Line

Medium weight line with short dashes. The size of the dash is approximately $1/8"$, but will vary with the size of the drawing. The hidden line represents those edges or surfaces that are invisible at point of observation.



3. Center Line

Light broken line consisting of long ($3/4"-1\frac{1}{2}"$) and short ($1/16"-1/8"$) dashes. This will vary with size of drawing. It is used to locate centers of holes, parts of circles, such as arcs, and to indicate symmetry or the center of a cylinder.



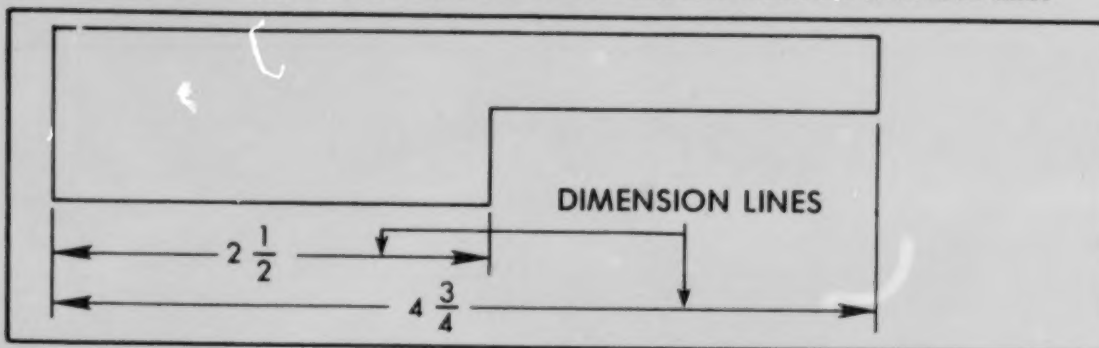
4. Extension Line

Medium solid line extending from the edge of the object for the purpose of indicating distances between two edges for dimensioning. The extension line does not touch the line it extends from and is normally placed outside the object.



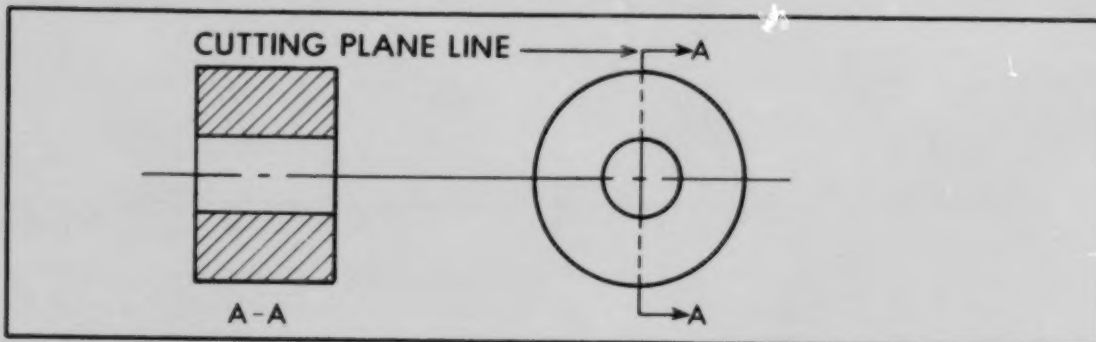
5. Dimension Line

Medium solid line usually broken near the center to allow for the dimension, although the break can vary to accommodate dimension or for clarity. Arrowheads terminate the ends of the dimension line and touch the extension line.



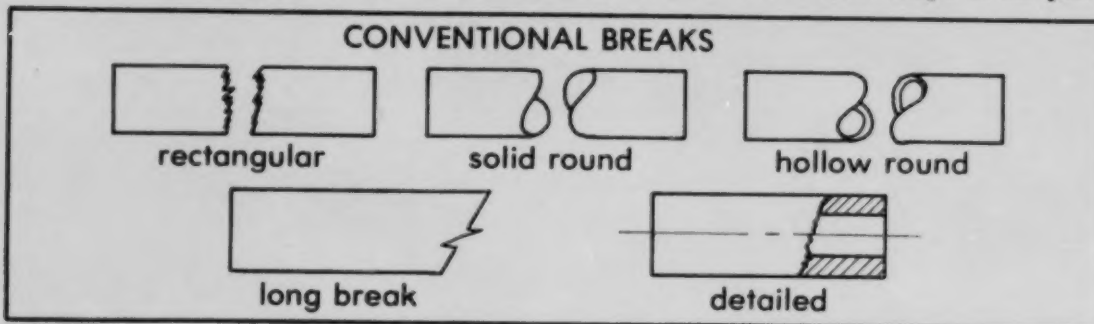
6. Cutting Plane Line

Heavy broken line consisting of long dash ($3/4'' - 1\frac{1}{2}''$) and two short dashes ($1/16'' - 1/8''$) that represents the edge of a cutting plane for the purpose of showing a sectioned view. At the end of the line arrows are connected and point in the directions that observation of the part is made. In some cases a letter is placed near each arrowhead to identify the section.



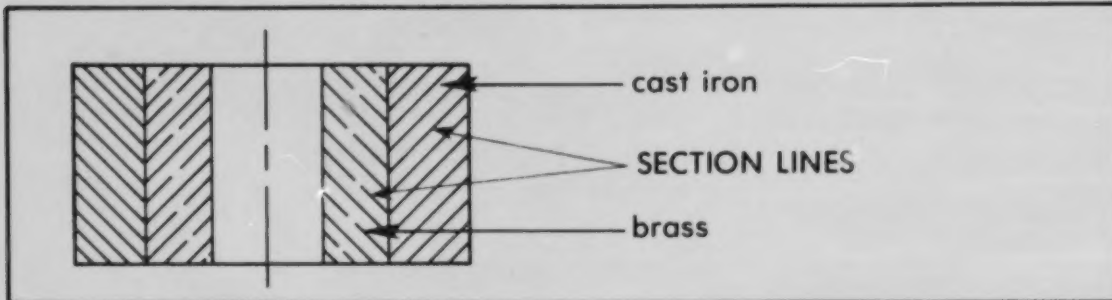
7. Break Line

Heavy solid line normally freehanded to indicate a part that has been removed from the print. It is used to eliminate large drawings to save space or to show the internal shape of a part. It does not alter the true size or shape of the part.



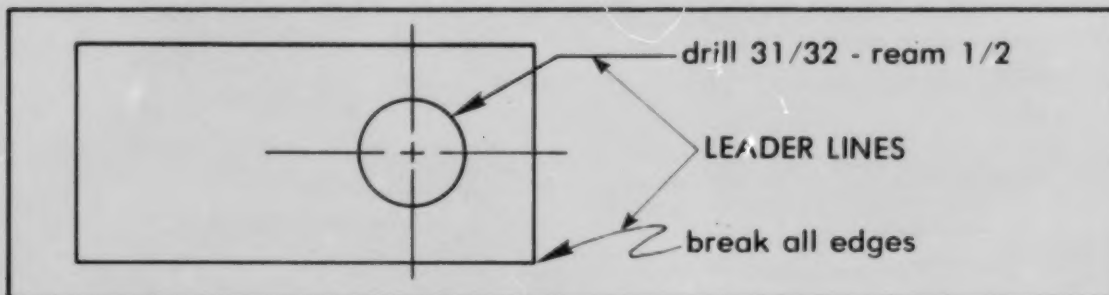
8. Section Line

Medium weight line, equally spaced and usually drawn at 30° , 45° , 60° across the visible edges of an imaginable cut surface. It is used to indicate a cut surface, assembled parts, or the type of material the part is made from. Cast iron is generally used for showing a cut surface.



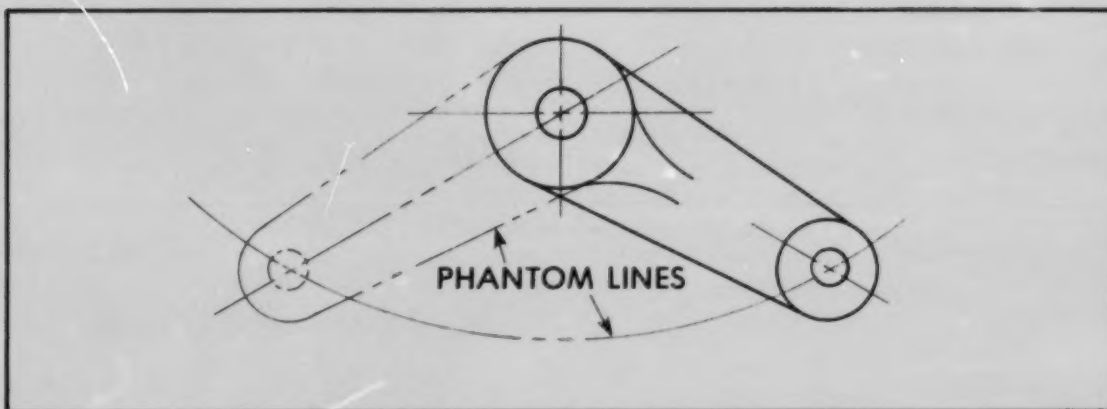
9. Leader Line

Solid line drawn as an angled or curved line with an arrowhead at one end. The leader line is used to refer a note to a certain part of the drawing.



10. Phantom Line

Very light line consisting of alternating long dash and two short dashes (similar to cutting plane line) for the purpose of indicating position of absent part in relation to the view that is drawn; for showing alternate position; special tool positioning or how part is held.



ASSIGNMENT SHEET
ON
ALPHABET OF LINES

II-B-1(AS)

- SUBJECT:** Conventional Lines Used In Drawing
- AIM:** The student will properly identify, correctly draw, and interpret the use of those conventional lines used in drawing and print reading.
- INTRODUCTORY INFORMATION:** Conventional lines called "the alphabet of lines" are the basis for all drawings, regardless if orthographic or pictorial; industrial or architectural; mechanically drawn or sketched. Each line is made a certain weight, size, and either as a solid line, broken line, or a combination of both. The way the line is drawn gives meaning to the line in the interpretation of the drawing. To be able to accurately read a print requires the ability to interpret the meaning of each line. Upon completion of this assignment sheet the student will be able to identify, interpret the meaning, and correctly draw those conventional lines used in drawing.
- REFERENCE:** Information Sheet II-B-1(IS) "Alphabet Of Lines"
- QUESTIONS OR PROBLEMS:** In Assignment Sheet II-B-1(AS) the student will identify the given line by sketching each line correctly and showing an example of use for each line as illustrated in the given example.

ASSIGNMENT SHEET
ON
ALPHABET OF LINES

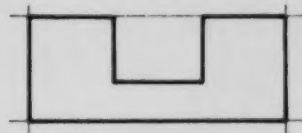
II-B-1(AS)

NAME _____

DATE _____

DIRECTIONS: Sketch each of the following lines correctly. Show example of use of each.

EXAMPLE: Construction Line: _____



1. Object Line:
2. Hidden Line:
3. Phantom Line:
4. Cutting Plane Line:
5. Section Line:
6. Long Break Line:
7. Short Break Line:
8. Extension Line:
9. Dimension Line:
10. Center Line:
11. Leader Line:

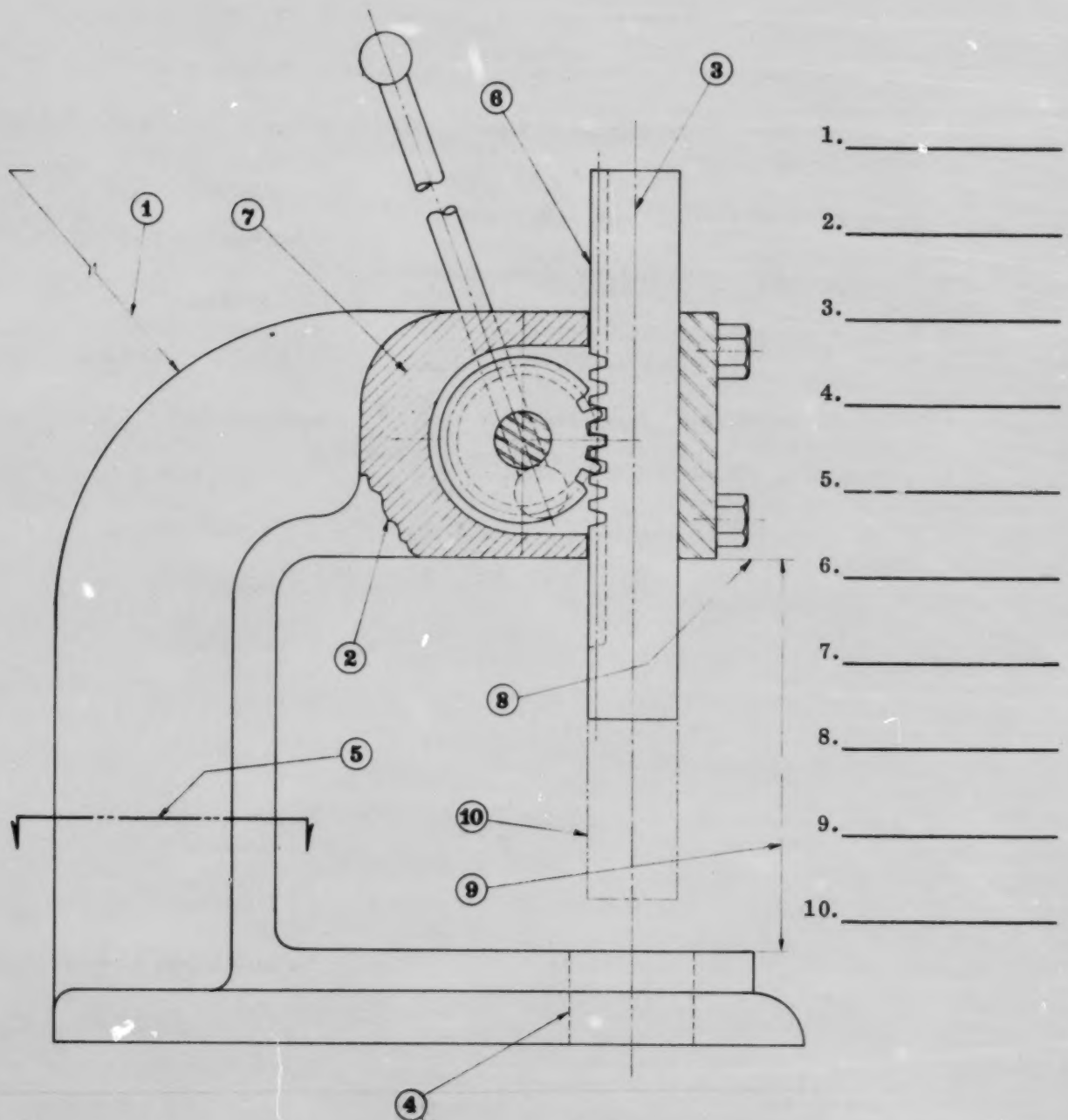
PICTORIAL RECALL TEST
ON
ALPHABET OF LINES

II-B-1(T)
p. 1 of 2

NAME _____

DATE _____

DIRECTIONS: Identify each of the lines indicated in the illustration below. Write the correct answer in the space provided.



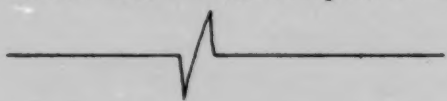
MATCHING TEST

II-B-1(T)
p. 2 of 2

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

Column I

Column II

- | | |
|---|-----------------------------------|
| ___ 1. Indicates symmetry | A. Phantom Line |
| ___ 2. Represents invisible edges | B. Section Line |
| ___ 3. Gives distances between two edges | C. Broken |
| ___ 4. Imaginary plane for the purpose of showing a sectioned view | D. Extension Line |
| ___ 5. Used to shorten large drawing | E. Cast Iron |
| ___ 6. Indicates type of material or shows assembled parts | F. Dimension Line |
| ___ 7. Shows the main visible shape of the part | G. Alphabet of Lines |
| ___ 8. Gives reference from which a dimension is given | H. Cutting Plane Line |
| ___ 9. Used to show alternate position | I. Break Line |
| ___ 10. Standardized and adopted the lines used in print reading | J. Hidden Line |
| ___ 11. Lines may be solid or ___ | K. Center Line |
| ___ 12. Common name for the lines | L. Leader Line |
| ___ 13. Common cross hatch line used to show a sectioned surface | M. Object Line |
| ___ 14. Refers note to a certain part of the drawing | N. A. M. A. |
| ___ 15.  | O. Thick Line |
| | P. American Standards Association |
| | Q. Thin Line |
| | R. Long Break Line |

INFORMATION SHEET
ON
PRINT READING

II-B-2(IS)

SUBJECT: Theory of Multi-View Drawings

INTRODUCTORY
INFORMATION:

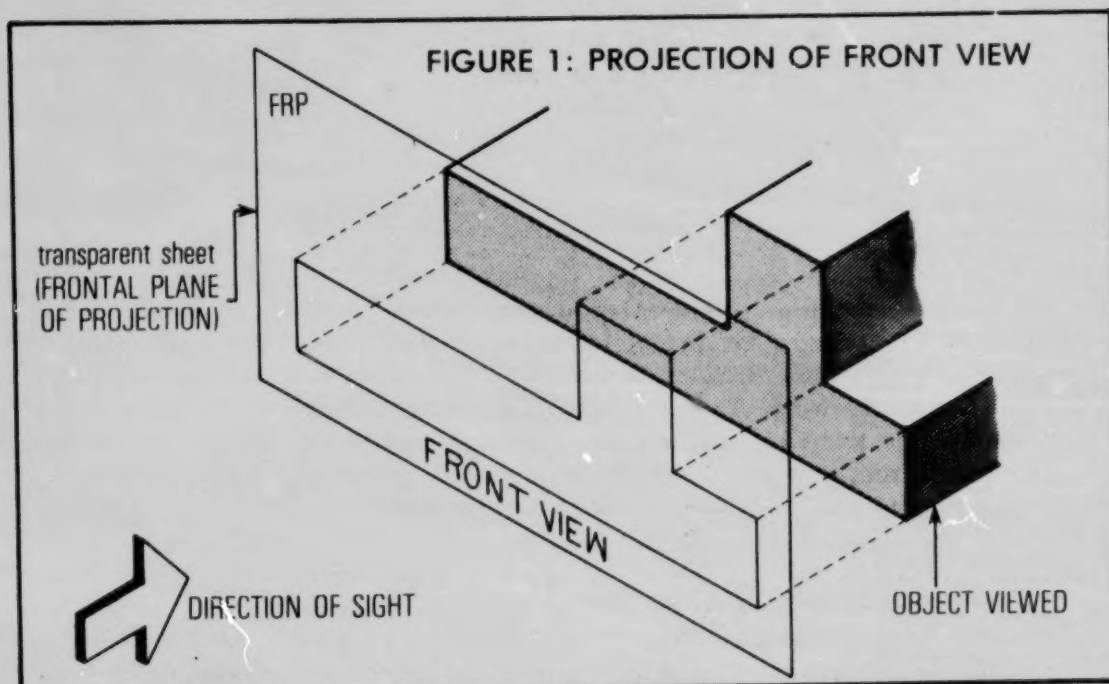
The system of technical or engineering drawing used on most prints in industry is referred to as orthographic projection or multi-view drawing. The machinist often refers to it as a work drawing because all information required to produce the part is given in the drawing. The orthographic drawing, unlike the pictorial drawing that shows a picturelike view that is easy to understand but does not present the object in its true shape, presents the object as it actually is, giving all necessary views and information required to completely describe the object.

It is the job of a draftsman to represent the part to be produced by means of a drawing. The machinist must produce the part on the basis of the information contained in the drawing. To do this effectively, the machinist must first be able to visualize the part to be manufactured. The ability to read and interpret a drawing quickly and accurately is important to industry in the terms of time and production, which means money to the company.

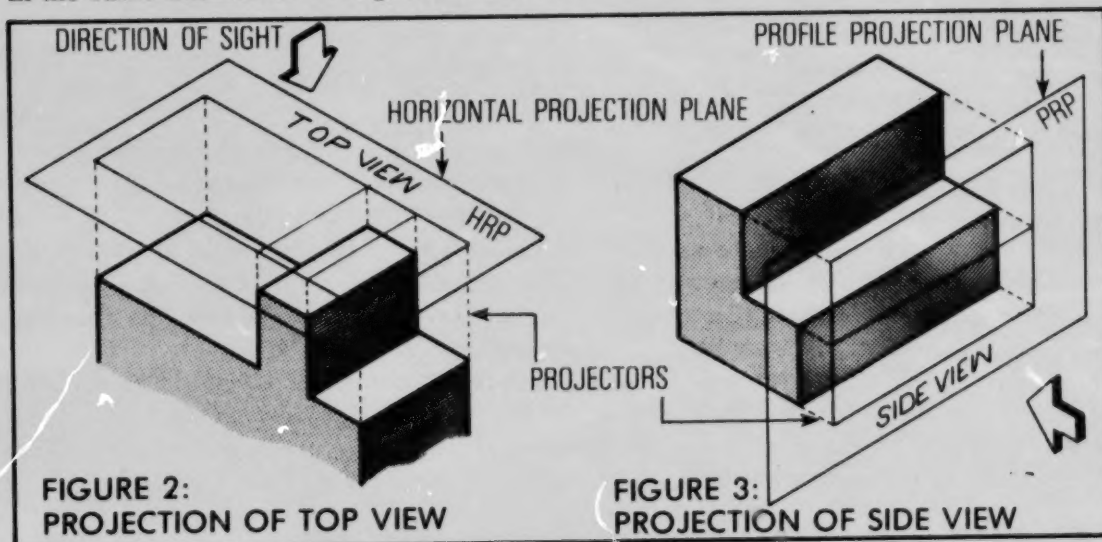
GENERAL INFORMATION

Multi-View Projection (Orthographic)

An orthographic projection is the projection of an object onto an imaginary plane called "the plane of projection". The plane of projection, placed between the viewer and the object, is vertical and square with the line of sight of the viewer. These lines of sight are referred to as lines of projection. The object is theoretically viewed at eye level with the viewer an infinite distance from the object, so that the lines of sight are parallel. Let us assume that the person who makes the drawing places a transparent sheet or glass directly between self and the object, and traces the outline of the object as it appears through the transparent sheet. The outline would portray that view or side of the object in true shape, as seen in Figure 1. The viewer would not be able to detect depth in the object. The projection plane in this case is frontal plane; therefore, the view is the front view.



To get a more complete representation of the object, let us project two other views in the same manner as in Figures 2 and 3.



In Figure 2, the object is viewed through a horizontal projection plane, which is perpendicular to the frontal plane; thus, the top of the object is viewed. By the same thought, in Figure 3, the object is viewed through the profile plane which is perpendicular to the frontal and horizontal plane. As a result, we have three planes of projections or views that are perpendicular to each other and form a box-like figure as in Figure 4.

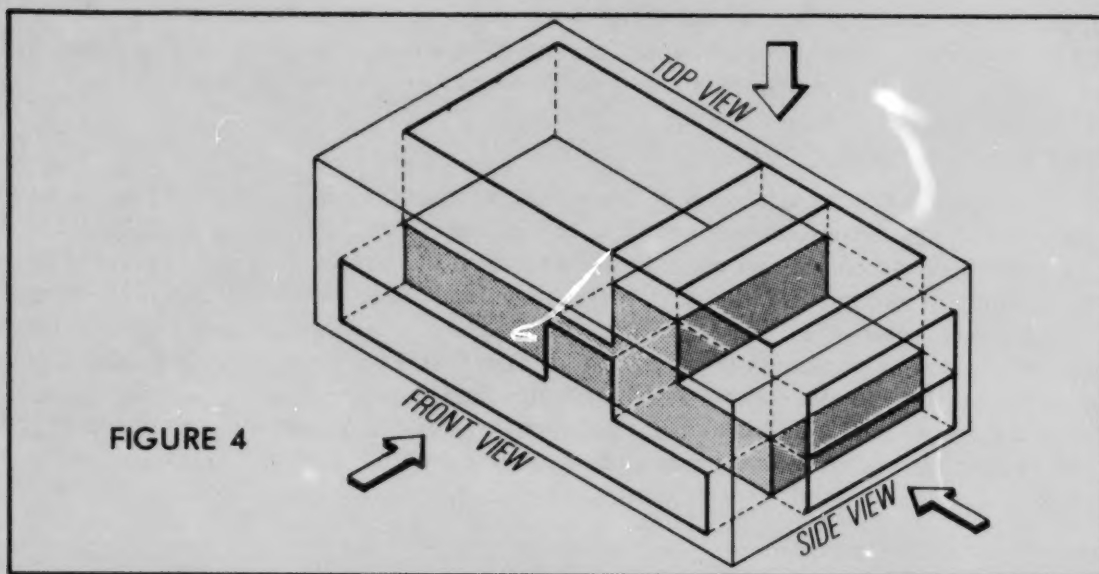


FIGURE 4

The object can be considered in the same way as a block, having six regular sides, thereby containing six normal views of projection. We have already viewed our object from the front, top, and side, and we can continue by observing the bottom, back, and left side in the same manner.

Another way to visualize a multi-view drawing is by enclosing the object with a glass box whose sides are parallel to the sides of the object. The sides of the glass box represent the planes of projection. In observing, we find that the bottom, left side, right side, and top are hinged to the front, with the back hinged to the left side, as in Figure 5. Upon opening the box or unfolding each side to the box 90° , the sides or views take their respective positions with each other. All views take their position directly above, below, or to one side or the other of the front view, with the back view to the left side.

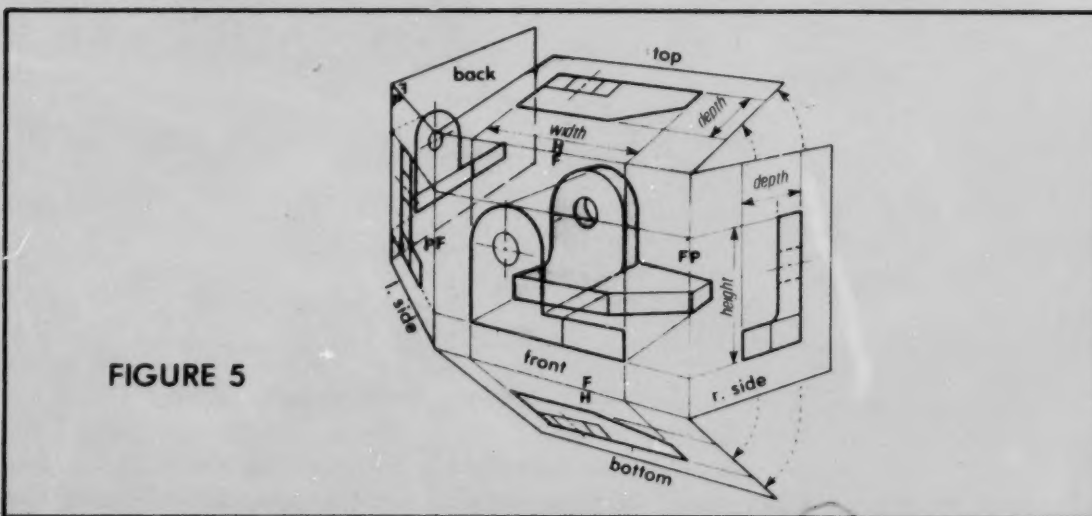
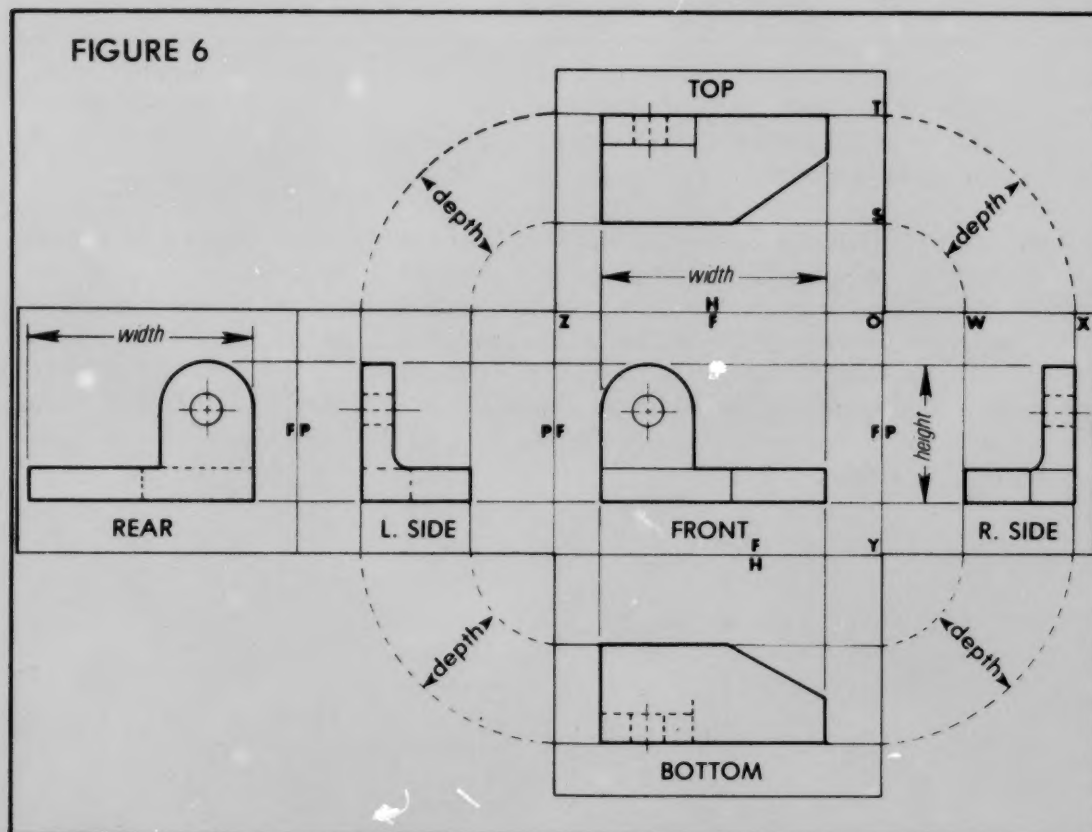


FIGURE 5

As we view an object, we find that it has three principal dimensions; namely: width, height, and depth. These terms are fixed for dimensions regardless of the shape of the object, although sometimes another term would seem more appropriate.

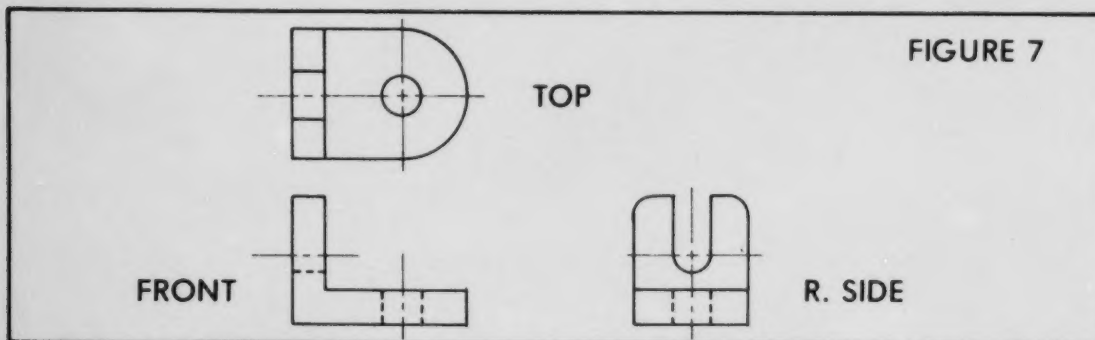
Principal Dimensions of an Object

Each view of an object contains only two principal dimensions. For example, in the front view the principal dimensions are height and width. By the same token, the back view also has height and width as the principal dimension. In the side (profile) views, height and depth are the principal dimensions, while depth and width are seen in the top and bottom (horizontal) views. In Figure 6, where the planes of projection of the glass box are unfolded so as to see all six views in their relative position, note the principal dimensions contained in each view and those with common dimensions. The front, rear, and side views have height as a principal dimension, while the top, front, rear, and bottom views have width as a principal dimension. The top, bottom, and side views have depth as a principal dimension.



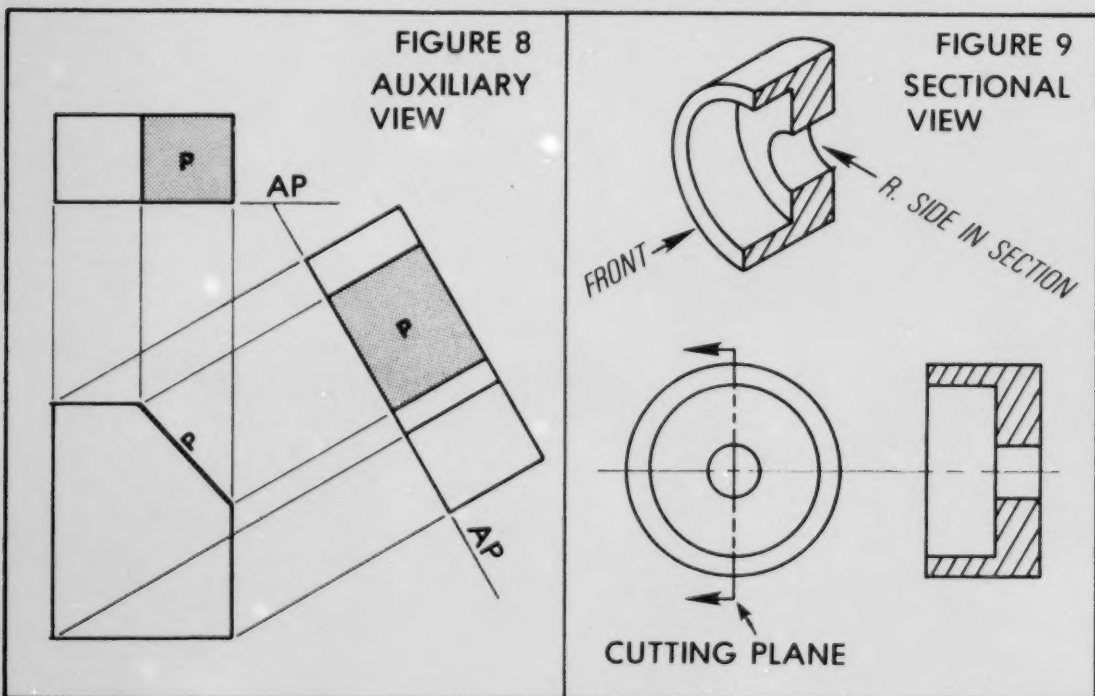
From this it is easy to understand that in order to completely describe an object requires at least two views, except in special cases where a single view and a note can be used. In more complex objects, three and sometimes additional views are required. As a general practice, the front view is selected first, and normally the

top and right side view would be used where necessary, as in Figure 7. Although this is the general practice, it is not absolute that these are the only views used, as in some cases the left side view may be the best selection. The normal rule followed is: "whatever it takes to clearly convey the information necessary to construct or manufacture a part." This includes special views such as the auxiliary and sectional view.



Special Planes of Projections

Where highly detailed or complex parts are shown, views may be used to show inclined surfaces or the interior of complex parts. There are two types of special planes of projection: (1) auxiliary planes for the projection of views that are not parallel with any normal plane or view, (see Figure 8); and (2) sectional cutting planes for describing the interior of complex parts (see Figure 9). Both of these special planes of projection will be covered individually in a later lesson.



ASSIGNMENT SHEET
IN
PRINT READING

II-B-2(AS)

SUBJECT: Multi-View Drawings

AIM: The student will be able to exhibit those skills necessary to correctly read a multi-view drawing by sketching in those missing lines that will make each view of the given object correct.

INTRODUCTORY INFORMATION: In the reading of a multi-view drawing a person must be able to visualize the object in three dimensions. An object consists of various geometric figures that intersect each other. Where they intersect forms an edge that may be a straight line or a curved line. The line may be vertical, horizontal, inclined, or curved. It may be a hidden line in one view and a visible line in another. These assignment sheets are designed to help the student understand the relationship between the views of a given object. In working these assignments, it should be kept in mind the manner in which views of an object may be imagined projected onto the sides of a transparent box. Review Information Sheet II-B-2(IS) "Theory of Multi-View Drawing" before beginning the assignment.

REFERENCES: Information Sheet II-B-2(IS) "Theory of Multi-View Drawing"
Information Sheet II-B-1(IS) "Alphabet of Lines"

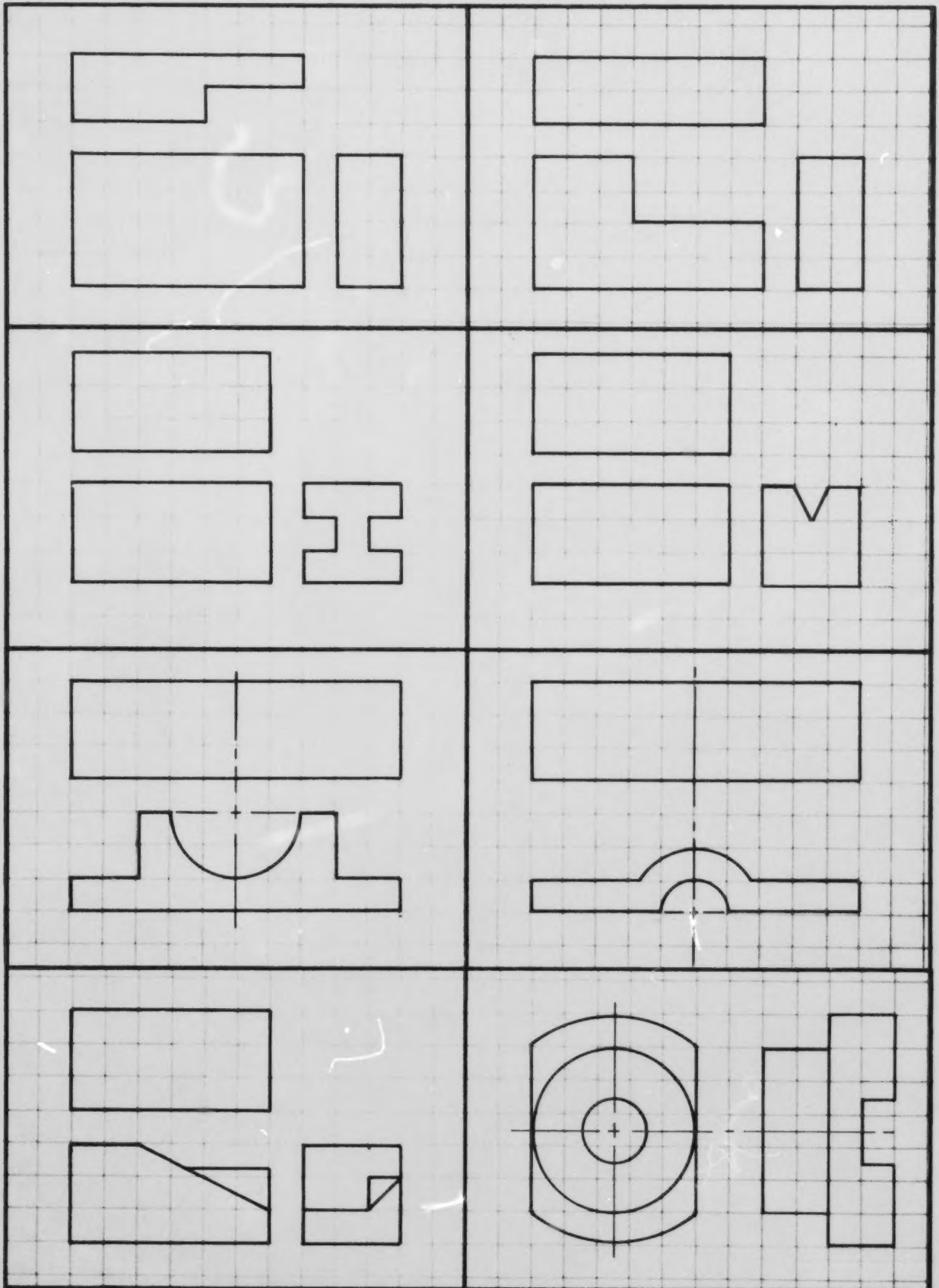
QUESTIONS OR PROBLEMS: In the given problems, study the given views and sketch in those missing lines that would make each view complete and correct. Some problems will have only two views given as that is all that is required to describe the object. The student is to work Assignment Sheet II-B-2(AS) as instructed by the instructor.

MISSING LINE EXERCISE #1

II-B-2(AS)

Name: _____

Date: _____

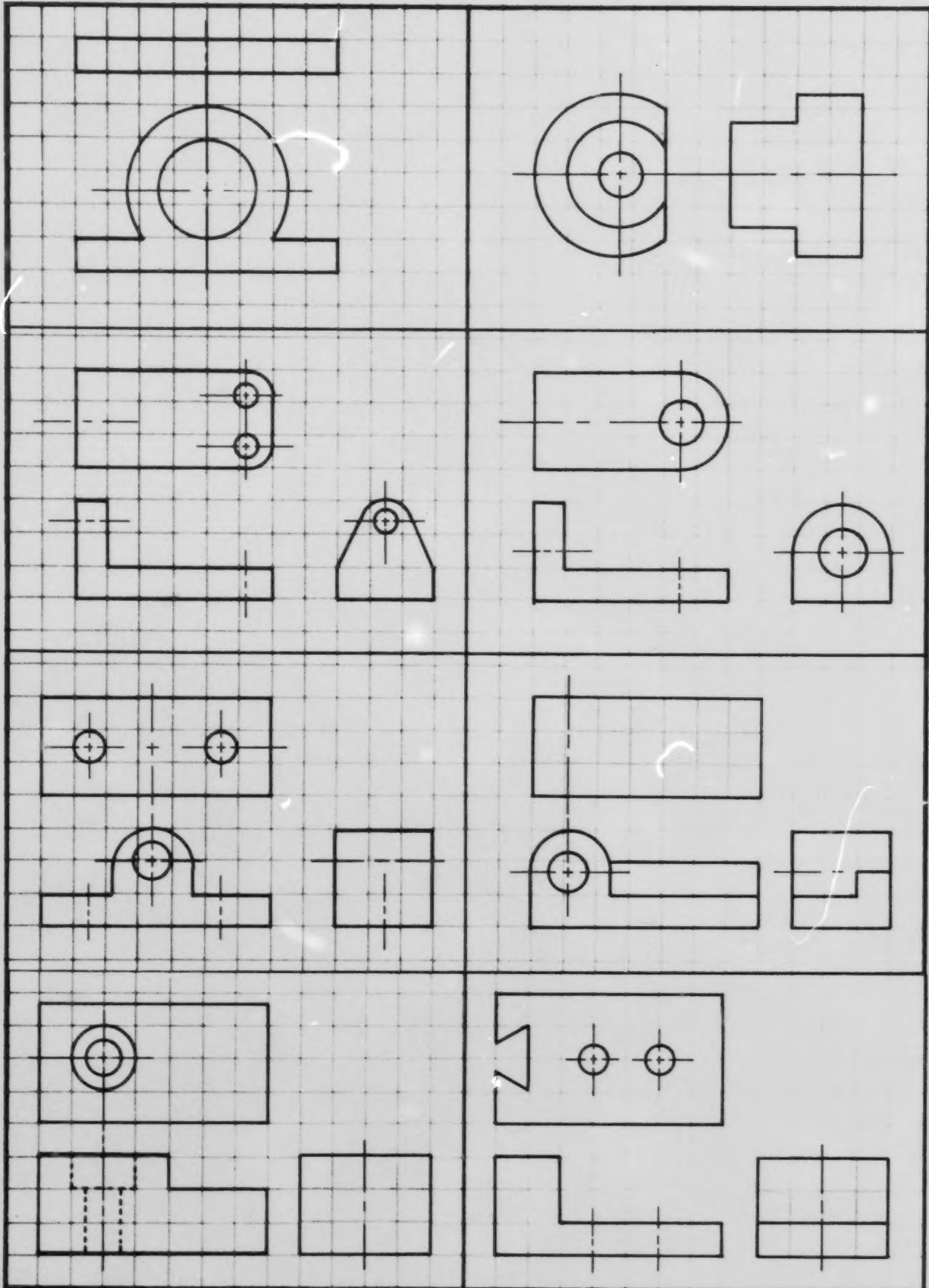


MISSING LINE EXERCISE #2

II-B-2(AS)

Name: _____

Date: _____



ASSIGNMENT SHEET
IN
PRINT READING

II-B-2a(AS)

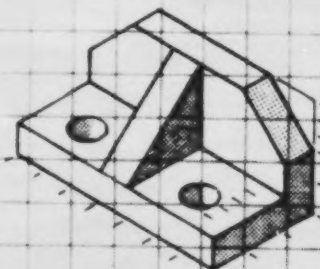
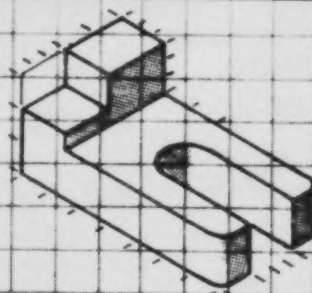
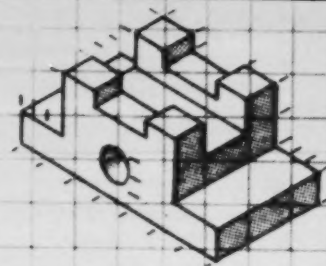
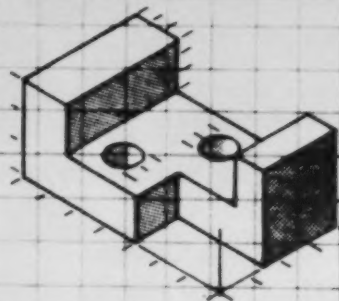
SUBJECT:	Multi-View Drawings
AIM:	The student will be able to further develop the skills of reading multi-view drawings by examining the pictorial drawing given and completing the multi-view drawing by adding the necessary lines.
INTRODUCTORY INFORMATION:	In Assignment Sheet II-B-2(AS) the student examined each of the given views of an object and sketched in the necessary lines that would make each view complete and correct. In this assignment the student will continue the study of multi-view drawings so as to further those skills required in print reading.
REFERENCES:	Information Sheet II-B-1(IS) "Alphabet of Lines" Information Sheet II-B-2(IS) "Theory of Multi-View Drawing"
QUESTIONS OR PROBLEMS:	The following assignment sheets are provided to give the student further practice in understanding the relationship between views and the objects they represent by completing the drawings. The students will study the pictorial drawing and sketch the three views of the object completely showing all visible, hidden, and center lines.

MULTI-VIEW EXERCISE #1

Name: _____

II-B-2a(AS)

Date: _____



42

43

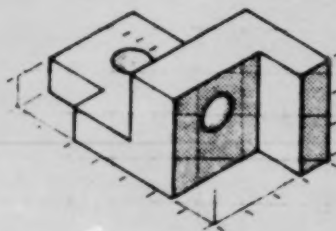
39

MULTI-VIEW EXERCISE#2

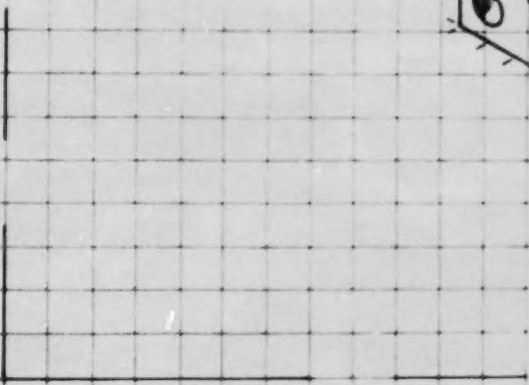
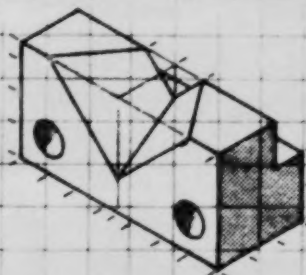
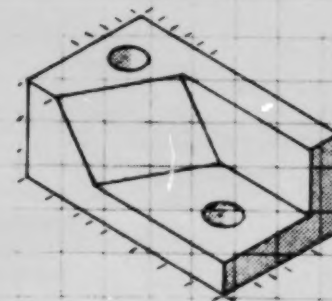
Name: _____

II-B-2a(AS)

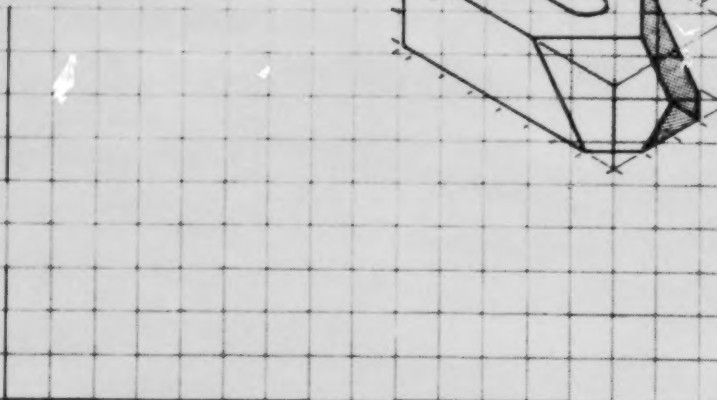
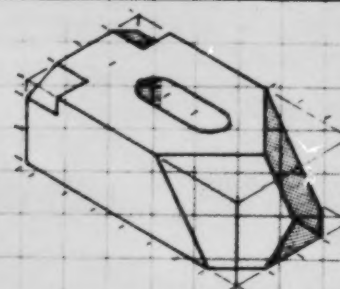
Date: _____



41



44



45

MATCHING TEST
ON
MULTI-VIEW DRAWINGS

II-B-2(T)
p. 1 of 3

NAME _____

DATE _____

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

Column I

Column II

- | | |
|--|-------------------------|
| ____ 1. Provides complete size and shape description | A. Plane of Projection |
| ____ 2. Relationship of regular views | B. Height |
| ____ 3. Projection of front view | C. Principal Dimensions |
| ____ 4. Imaginary plane perpendicular to line of sight | D. Width |
| ____ 5. Projected onto horizontal plane | E. Multi-View Drawing |
| ____ 6. Projection of inclined surface | F. Six |
| ____ 7. Height, width, and depth | G. Frontal Plane |
| ____ 8. Normal views of an object | H. Depth |
| ____ 9. Shows interior features | I. Perpendicular |
| ____ 10. Dimension common to front and top view | J. Work Drawing |
| ____ 11. Dimension common to top and side view | K. Pictorial Drawing |
| ____ 12. Multi-view drawing | L. Auxiliary View |
| ____ 13. Principal dimension measured from top to bottom | M. Third Angle |
| ____ 14. U.S. standard method of projection | N. Sectional View |
| ____ 15. Indicates where part is cut | O. Parallel |
| | P. Cutting Plane |
| | Q. Top View |

**MISSING LINE TEST
ON
MULTI-VIEW DRAWINGS**

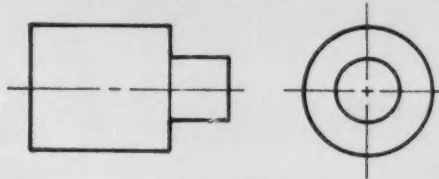
II-B-2(T)
p. 2 of 3

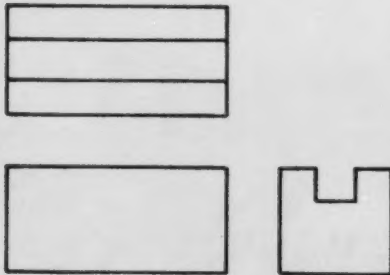
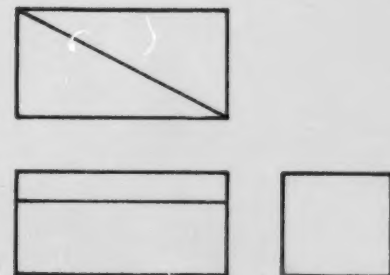
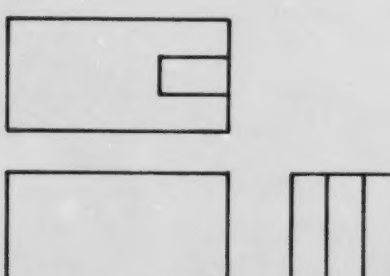
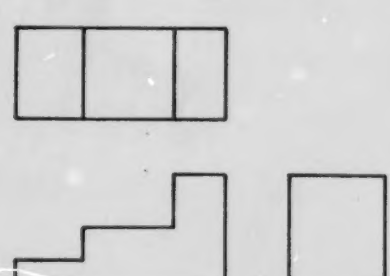
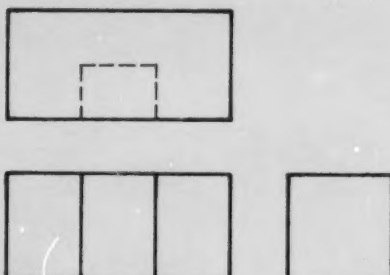
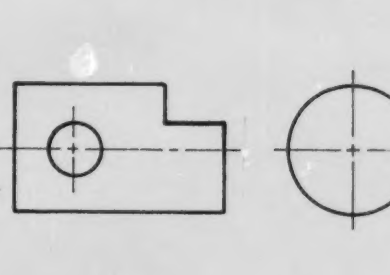
NAME: _____

DATE _____

DIRECTIONS: In the problems below, study the three views given and sketch in those lines missing that would make the views complete.

EXAMPLE:



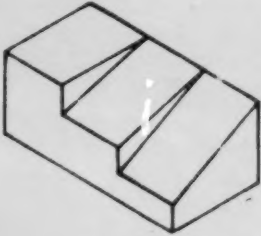
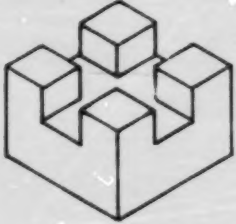
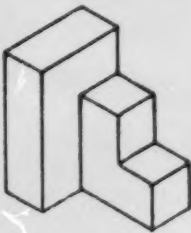
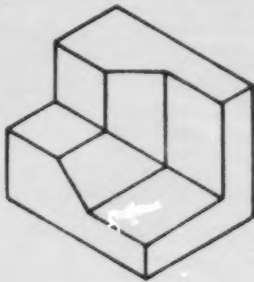
MISSING VIEWS TEST
ON
MULTI-VIEW DRAWINGS

II-B-2(T)
p. 3 of 3

NAME: _____

DATE _____

DIRECTIONS: Study carefully the pictorial drawing given in each of the problems below. Sketch all three views of the object in the space provided. Show all visible, hidden, and center lines.

INFORMATION SHEET
ON
PRINT READING

II-B-3(IS)

SUBJECT: Dimensions and Dimensioning Practices

INTRODUCTORY
INFORMATION:

Drawings consist of lines that describe the exterior shape and internal construction of an object. However, for that object to be constructed or machined, the drawing must provide information as to the exact size and location of surfaces, holes, and configurations.

Dimensions on a drawing should be complete to the point that a minimum amount of computation will be required and the part may be made without scaling the drawing.

Some parts cannot be drawn full size because they are too large to fit the drawing sheet, or may be too small to show all details clearly. In cases such as this, the drawing is enlarged or reduced by letting one unit of measure represent another. An example of this would be letting 1" = 2" to reduce the size or have 2" = 1" to enlarge the size of the part. The scale of the drawing can be found in the title box. An example would be: Scale: 2" = 1". However, this practice of enlarging or reducing the size of the drawing does not affect any of the dimensions as the dimensions give the actual sizes of the part.

Types of Dimensions

As previously stated, dimensions are used to give information as to size and location of geometric figures, such as, prisms, cylinders, cones, pyramids, and spheres, as seen in Figure 1.

In dimensioning an object, the dimensions must give the size of each geometric figure, "size dimensions," and the exact location of each surface, "location dimension." For example, to drill a hole in a part, the machinist must know three things: (1) the diameter of the hole (size dimension); (2) the exact location of the center (location dimension), and (3) depth of hole. These basic dimensions can be broken down into four types of dimensions given that are required in reading the drawing. These dimensions are: (1) overall dimensions of the part; (2) shape dimensions of each geometric figure; (3) location dimensions, locating each geometric figure with each other or a reference edge; and (4) notes or descriptors, that give information as to size and procedure. Example: $\frac{1}{2}$ drill $3/4$ " deep - 4 holes, as in Figure 1.

In general, size dimensions give a complete description of a surface while location dimensions gives the location of a surface from a finished surface, given as a datum plane, or from an important center or center line.

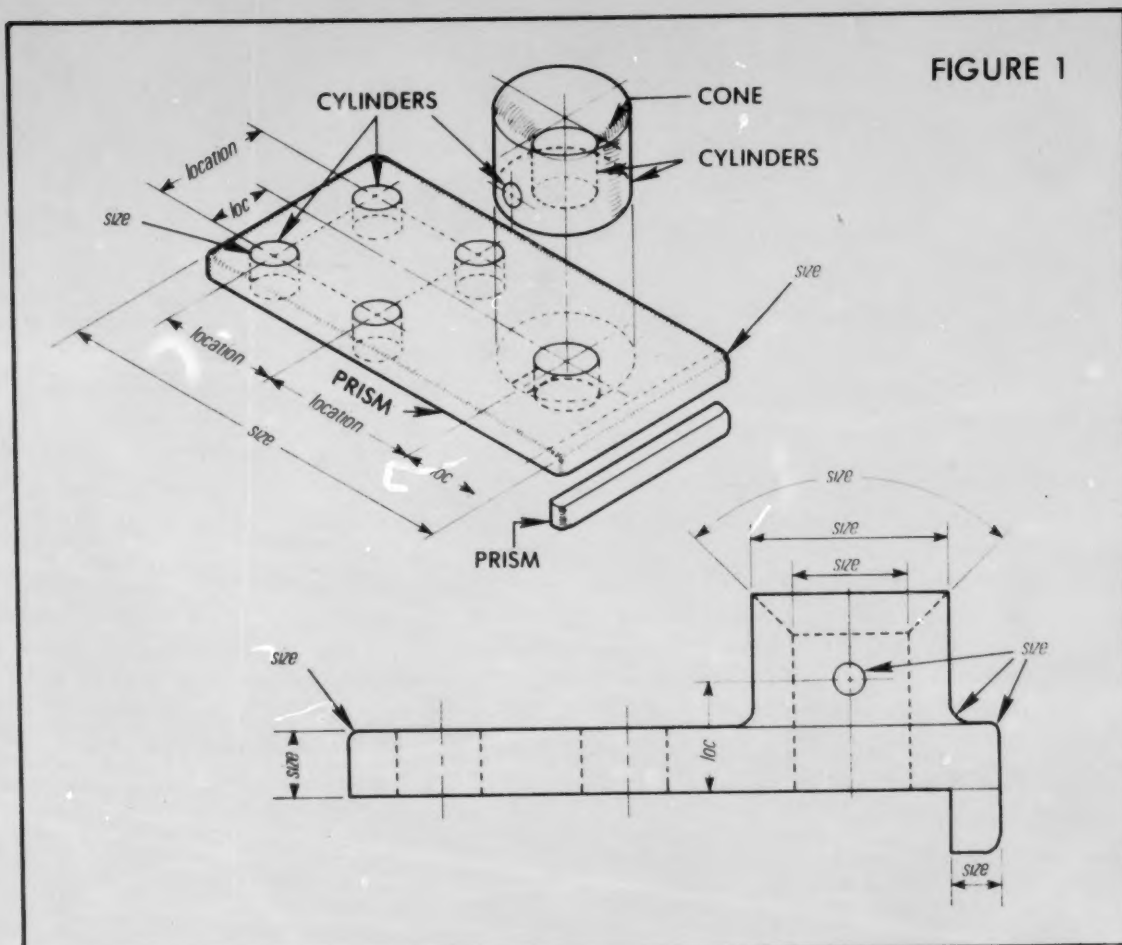


FIGURE 1

Dimensioning

In dimensioning an object, the way the dimension is recorded is determined by the degree of accuracy required and the type of dimension. Generally speaking, dimensions are recorded in fractions, decimals and by degrees. As industry converts more and more to the metric system, the use of metric dimensions will be used. For the present we will concern ourselves with the use of the English System.

Fractional Dimensions, commonly referred to as "scale dimensions," are called for where a high degree of accuracy is not required. Accuracy of this type of dimension is usually held to a $\pm 1/64"$ of the given dimension. This is called the tolerance of a dimension and as long as the finished part is within the maximum and minimum limits it is acceptable. That is to say, on a part with a specified dimension of $6 \frac{7}{8}"$, the maximum acceptable size (limit) would be $6 \frac{7}{8}" + 1/64" = 6 \frac{57}{64}"$; the minimum acceptable size (limit) would be $6 \frac{7}{8}" - 1/64" = 6 \frac{55}{64}"$. Therefore, as long as the finished size is within these limits it is acceptable. The tolerance for fractions are usually accepted as $\pm 1/64"$ unless otherwise specified. This will normally be noted in the title box.

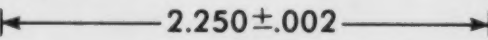
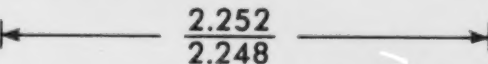
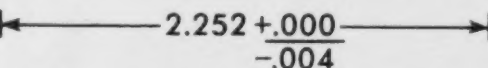
Decimal Dimensions

Decimal dimensions may be expressed in hundredths of an inch (.01"), thousandths of an inch (.001"), ten-thousandths of an inch (.0001"), and, occasionally, in hundred-thousandths of an inch (.00001"). Formerly, decimal dimensions were used where a high degree of accuracy was required, but the use of decimal dimensions in hundredths of an inch to replace the fractional dimension is becoming popular. In other words, .14" would replace $9/64$ " or 3.06" instead of $3 \frac{1}{16}$ ". Example:

Where decimal dimensions are used in place of fractions, the same tolerance ($1/64$ " or .016") is used.

Decimal dimensions in thousandths are used on parts requiring a greater degree of precision with less tolerance. The tolerance given to the dimension is determined by how precision the part must be. An example of this would be the dimension $2.625 \pm .0004$. The tolerance $\pm .004$ " means that the size of the part can be from 2.629" (maximum limit) to 2.621" (minimum limit). Thus the part is acceptable if it measures between 2.629" and 2.621".

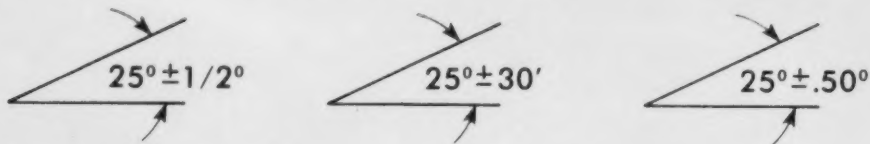
Tolerance dimensions may be given as a note in the title box as: "Unless otherwise specified limits on decimal dimensions are $\pm .005$ inches," or on the drawing by one of three ways, as in examples below:

1. 
2. 
3. 

In each of the above dimensions the tolerance is .004", the difference between the maximum limit and minimum limit.

Angular Dimensions

The size of angles are expressed in degrees ($^{\circ}$) or parts of a degree, such as minutes ($'$) and seconds ($''$). Angular tolerances may be given in the dimension as below:



In this example, the finished angle may be as much as 30 minutes above or below the specified angle.

The tolerance of angles may also be given in note form in the title box as: "Unless otherwise specified limits on angular dimensions are $\pm 2^{\circ}$ ".

ASSIGNMENT SHEET
IN
PRINT READING

II-B-3(AS)

- SUBJECT:** Interpretation of Dimensions, Notes, and Symbols
- AIM:** The student will be able to read, interpret, and accurately record information given by dimensions, notes, and symbols from a given print and by identifying abbreviations that are frequently used.
- INTRODUCTORY INFORMATION:** The ability to visualize an object as it appears on a drawing is not sufficient to manufacture a part. To complete the description of a part requires complete shape description, as in Assignment Sheet II-B-3(AS), and size description. Size descriptions are given by applying dimensions in fractions, decimals, and angles. These dimensions are supplemented by the use of symbols and notes, for the complete interpretation of a print requires the knowledge of how dimensions are given and the ability to interpret notes, symbols, and abbreviations that are used. Prior to working the following assignment, it is important that the student carefully study Information Sheets II-B-3(IS) "Dimensions and Dimensioning Practices" and II-B-3a(IS) "Abbreviations, Notes, and Symbols".
- REFERENCES:** Information Sheet II-B-3(IS) "Dimensions and Dimensioning Practices"
Information Sheet II-B-3a(IS) "Abbreviations, Notes, and Symbols"
- QUESTIONS AND/OR PROBLEMS:**
1. Assignment Sheet II-B-3(AS) requires the student to study the print and record the correct answer that corresponds to the given statement.
 2. Complete Assignment Sheet II-B-3a(AS) by filling in the blank that corresponds to the given abbreviation, note, or symbol with the term that correctly identifies it.

ASSIGNMENT SHEET
ON
DIMENSIONS, NOTES AND SYMBOLS

II-B-3(AS)

NAME _____

DATE _____

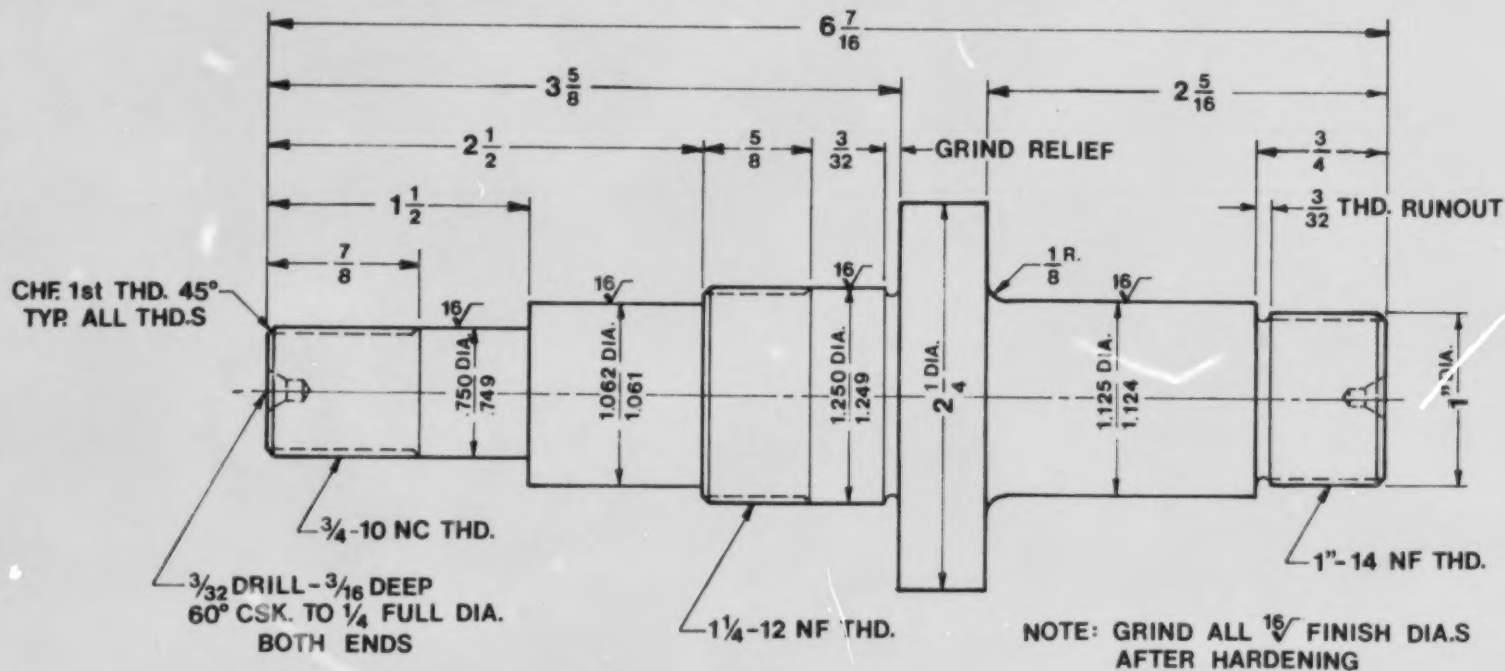
DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE:

1. Name of part

spindle shaft

1. Material used
2. Maximum size of $2\frac{1}{4}$ " diameter
3. Minimum chamfer angle on threads
4. Grind finish required
5. Minimum length of $\frac{3}{4}$ -10-NC thread
6. Lower limit of $1\frac{1}{16}$ " diameter
7. Type thread representation
8. Length of $1\frac{1}{4}$ -12 NF thread
9. Length of $2\frac{1}{4}$ " diameter
10. Size of center drill hole
11. Number of threads per inch on $1\frac{1}{4}$ " diameter
12. Minimum limit on $1\frac{1}{4}$ " diameter
13. Angle tolerance
14. Symbol for finished surface
15. Finish required on unspecified surfaces
16. Heat treat hardness specified
17. Number of parts required
18. Maximum allowable length of part
19. Size of thread relief
20. Size of fillet



MAT'L: 4140 H.R.S. ~ 2 REQ'D
H.T. 38-42 R/C

TOLERANCES UNLESS OTHERWISE NOTED		SPINDLE SHAFT	
FRACTIONS	$\pm 1/64$		
DECIMALS	$\pm .005$		
ANGLES	$\pm 1/4^\circ$	DWN. BY	DATE:
FINISHES	$125 \sqrt{}$	CKD. BY	SCALE:
		DWG. NO.	
		SHT. OF	

INFORMATION SHEET
ON
PRINT READING

II-B-3a(IS)

SUBJECT: Abbreviations, Notes, and Symbols

**INTRODUCTORY
INFORMATION:**

In a working drawing, it is often necessary to provide additional information which cannot be conveyed either by views or conventional dimensions. This information may consist of such items as: kind of material; type or degree of finish; operations, such as drill, ream, broach, or countersink; and the representation of threaded parts. To write out the information would not only be lengthy, but would create confusion in the reading and interpretation of the drawing. Through the use of notes, symbols, and abbreviations, the required information is given in a simple and distinct way.

To insure that the abbreviations, notes, and symbols used will have the same meaning, the American Standards Association provides a listing of those that are commonly used and accepted.

GENERAL INFORMATION

Abbreviations

Listed below are abbreviations of common terms that the machinist will come in contact with in reading prints.

<u>Word or Term</u>	<u>Abbreviation</u>
Addendum	ADD
Adjust	ADJ
American Institute of Iron and Steel	A. I. S. I.
Allowance	ALLOW
Alloy	ALY
Alternating Current	AC
Aluminum	AL
American Standard	AMER STD
American Wire Gage	AWG
Angle	ANG
American National Pipe Thread	ANPT
American Welding Society	AWS
Approximate	APPROX
Area	A
Assemble	ASSEM
Assembly	ASSY
Auxiliary	AUX

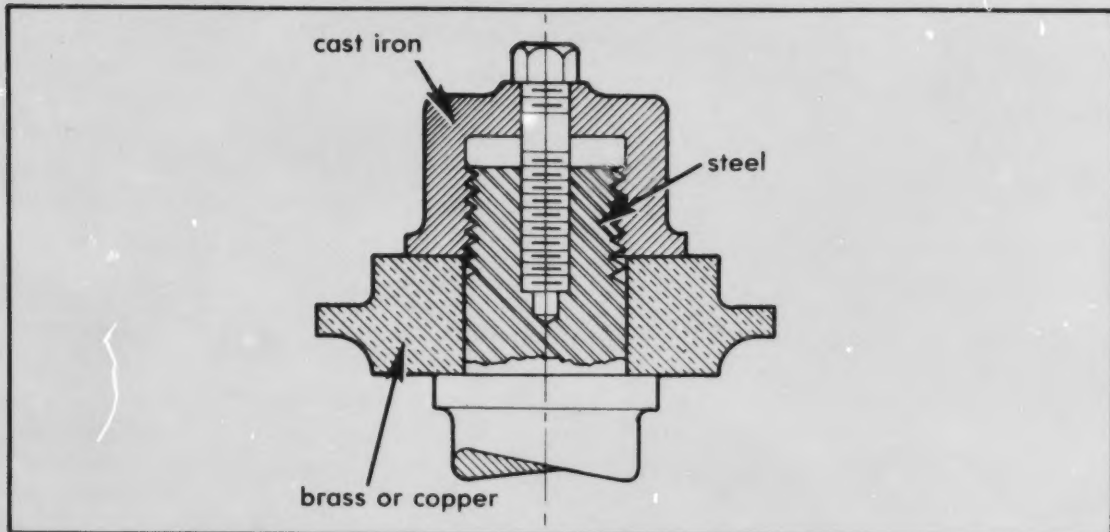
<u>Word or Term</u>	<u>Abbreviation</u>
Babbitt	BAB
Ball Bearing	BB
Bearing	BRG
Bill of Materials	B/M
Bolt Circle	BC
Brass	BRS
Break	BRK
Brinell Hardness Number	BH
Broach	BRO
Bronze	BRZ
Brown and Sharpe	B&S
Burnish	BNH
Cadmium	CAD
Carburize	CARB
Case Harden	CH
Cast Iron	CI
Cast Steel	CS
Casting	CSTG
Center	CTR
Center Line	CL
Chamfer	CHAM (CHF)
Chordal	CHOR
Circle	CIR
Circular Pitch	CP
Clearance	CL
Clockwise	CW
Cold Drawn	CD
Cold Drawn Steel	CDS
Cold Finish	CF
Corrected	CORR
Cosine	COS
Cotangent	COT
Counterbore	C'BORE
Countersink	C'SINK (CSK)
Counterclockwise	CCW
Counterdrill	C'DRILL
Dedendum	DED
Degree	DEG
Diagonal	DIAG
Diameter	DIA (d) (D)
Diametral Pitch	DP
Dimension	DIM
Double	DBL
Drawing	DWG
Drill	DR

<u>Word or Term</u>	<u>Abbreviation</u>
Eccentric	ECC
Feet Per Minute	FPM
Figure	FIG
Finish All Over	FAO
Fixture	FIX
Flat Head	FH
Forged Steel	FST
Full Indicator Reading	FIR
Gage	GA
Grind	GRD (3)
Harden	HDN
Head	HD
Heat Treat	HT TR (H. T.)
Hexagon	HEX
High Speed Steel	HSS
Height	HT
Horizontal	HOR
Hypotenuse	HYP
Included	INCL
Inside diameter	ID
Inspection	INSP
Keyseat	KST
Keyway	KWY
Left Hand	LH
Linear	LIN
Locate	LOC
Machine	MACH
Magnaflux	M
Magnesium	MAG
Material	MATL
Maximum	MAX
Minimum, minute	MIN
National	NATL (N)
National Coarse Thread	NC (UNC)
National Extra Fine Thread	UNEF NEF
National Pipe Thread	NPT
Nominal	NOM
Not to Scale	NTS
Number	NO
On Center	OC
Outside Diameter	OD
Overall	OA
Pattern	PATT
Pitch	P
Pitch Diameter	PD

<u>Word or Term</u>	<u>Abbreviation</u>
Plate	PL
Pounds Per Square Inch	PSI
Profile	PF
Radial	RAD
Radius	R
Ream	RM
Reduction	RED
Reference Line	REF L
Relief	REL
Revised	REV
Revolution Per Minute	RPM
Right Hand	RH
Rockwell Hardness	RH
Root Diameter	RD
Root Mean Square	RMS
Schedule	SCH
Screw	SCR
Shaft	SFT
Sheet	SH
Society of Automotive Engineers	SAE
Specifications	SPEC
Spot Face	SF
Standard	STD
Stainless Steel	SST
Surface	SUR
Symmetric	SYM
Tangent	TAN
Taper	TPR
Taper Per Foot	TPF
Tensile Strength	TEN/STR
Thread ..	THD
Threads/ Teeth Per Inch	TPI
Total Indicator Reading	TIR
Tolerance	TOL
Tooth	T
Typical	TYP
Universal	UNIV
Vertical	VERT
Volume	VOL (V)
Weight	WT
Weldment	WELD
Woodruff	WDF

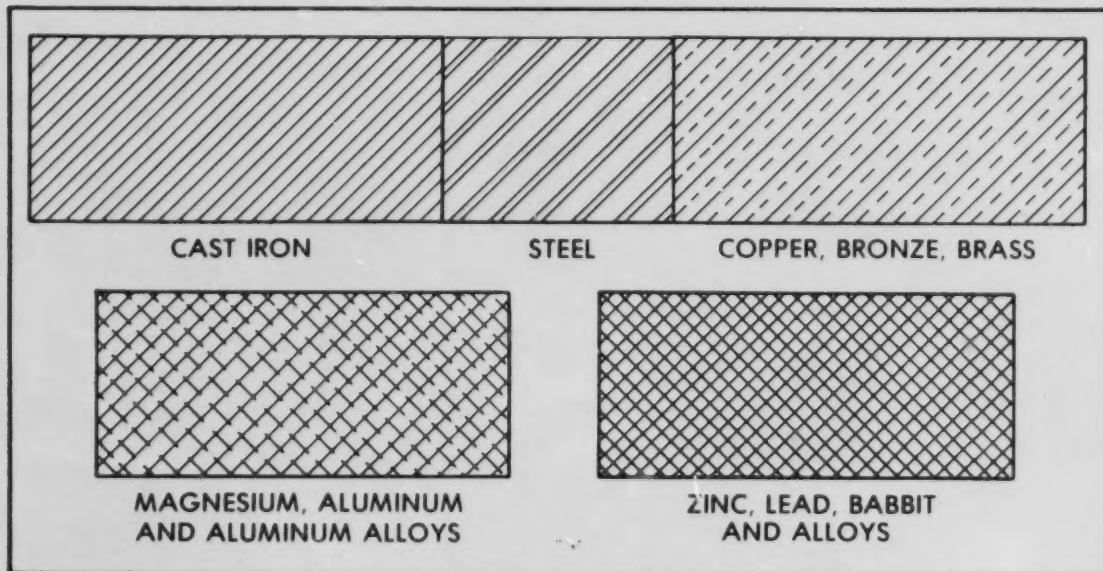
Material Symbols

In sectional views it is useful and convenient to distinguish the interior or sectioned part (material) the object from the machined surfaces. Conventional material symbols are used to show the interior part and also in clarifying sections where more than one kind of material is used, such as in assembled drawings. See Figure 1.



It is important to understand that material symbols represent the kind of material, but the exact composition, such as an alloy, is specified on the drawing by means of a note. Also, for most applications, the symbol for cast iron is used as a general purpose material symbol.

The most frequently used symbols are as follows:



Finish Symbols

The term "finished surface" applies to any surface that requires the removal of material to improve its shape, size, or smoothness. This is done by various machining processes such as turning, milling, drilling, grinding, broaching, or shaping.

A finish mark is used to indicate a surface that is to be machined or finished, such as on a rough casting. On drawings where the part is to be machined from rolled stock, finish marks would not be necessary as it is obvious that the surface is finished. An exception to this rule is where either the type of finish is called for, such as the non-control method which only specifies a finished surface (V) or the controlled finish which specifies the accepted finish in microinches (MU in. .000001), which is the present practice ($\sqrt{60}$). This method may also include the designation of maximum waviness height, maximum waviness width, and lay, or direction of predominant surface pattern ($\sqrt{63} \frac{002}{100} \perp$).

Modern inspection equipment, such as profilometers, which measure the irregularities. One method is the Arithmetical Average Height, which is the average of the total number of vertical measurements (Ave. Height = $\frac{A_1 + A_2 + A_3 + A_4}{4}$).

The second method is the root mean square (RMS), which is the number of readings taken on a profilometer squared (usually five) divided by the number of readings.

$$RMS = \sqrt{\frac{A^2 + B^2 + C^2 + D^2}{N}}$$

BOTH OF THESE METHODS CAN BE MEASURED ON THE PROFILOMETER.

The following illustrations are examples of finish marks used in drawings and their meanings.

Noncontrol Finish Marks

$\sqrt{\text{or V}}$ - indicates only that surface is finished

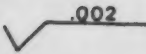
$\sqrt{G}$ - indicates the surface is to be ground

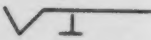
$\sqrt{M}$ - indicates only a machined surface

Control Finish Marks - Controls finish quality in terms of height, width, and direction of surface irregularities. The control finish mark may include all or part of the following notes:

$\sqrt{\quad}$ - Radical represents finished surface

$\sqrt{63}$ - Number represents roughness height measured in microinches (MU in.)

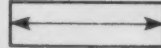
 - Represents maximum waviness height of surface irregularities measured in thousandths

 - Represents lay of surface as produced by direction of tool mark
May consist of one of the following:

 - Perpendicular



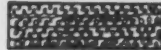
 - Parallel



X - Angular



M - Multidirectional



C - Circular



R - Radial



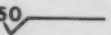
Micro Finish

Operation performed

1-16  - Scraped, lapped, or very fine ground

17-32  - Fine turned, reamed, or ground

33-125  - Medium turned, reamed, or ground

126-250  - Rough turned, ground, milled, planed, or sawed

251-500  - Very rough turned, milled, planed, or sawed

Auxiliary Symbols

In addition to the abbreviations and symbols that are used on prints or specification sheets, there are auxiliary type symbols that are used in the machinist trade. These symbols may be used on the print, specification sheets, or in material listings and calculations.

Below is a list of some of the more frequently used symbols and their meaning.

Meaning

& or § And

∠ Angle

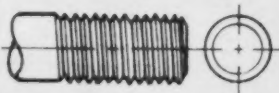
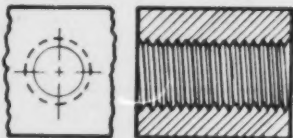
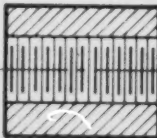
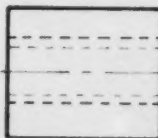
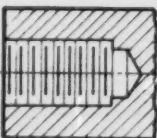
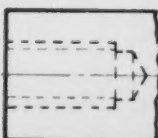
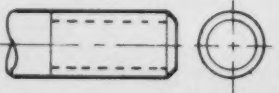
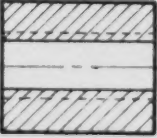
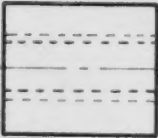
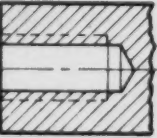
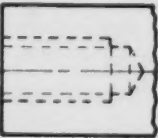
⤿ Arc

Meaning

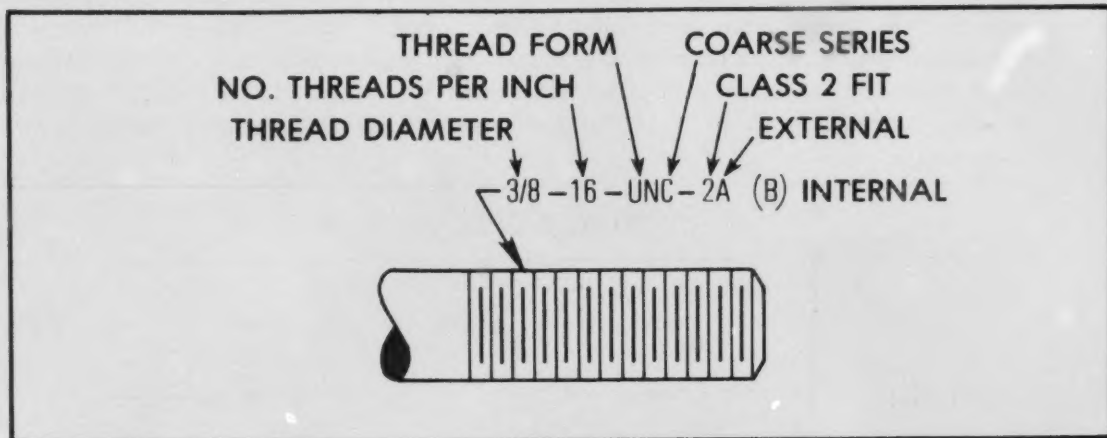
⊕	.....	Center Line
○	.....	Circle
°	.....	Degrees
÷	.....	Divide (into)
=	.....	Equal
'	.....	Feet or Minutes
"	.....	Inches or Seconds
-	.....	Minus (subtract)
//	.....	Parallel
+	.....	Plus (add)
%	.....	Percent
⊥	.....	Perpendicular
π	.....	Pi (3.1416")
:	.....	Ratio (is to)
φ	.....	Round Bar or Diameter
⊠	.....	Square Bar or Square
×	.....	Times (multiply)
△	.....	Triangle
▴	.....	Right Triangle

Thread Symbols

Thread symbols are used to represent threads of small diameter, usually one inch diameter or less, on the drawing. The symbols used are the same regardless of the form of thread, as Acme, American National, and Unified. There are two approved sets of symbols used, with choice a matter of company standards. For threads one inch and smaller the sets used are: (1) Schematic (Conventional) and (2) Simplified. On large threads, a graphic or detailed representation is used. See the following illustrations.

THREAD SYMBOL		
	EXTERNAL THREADS	INTERNAL THREADS
DETAILED		
SCHEMATIC (conventional)		   HOLE TAPPED THROUGH
		   TAP DRILL SHOWN
SIMPLIFIED		   HOLE TAPPED THROUGH
		   TAP DRILL SHOWN

Regardless of the method of representation used, the thread is specified by means of a standard notation which provides information concerning the thread, as illustrated in the figure below.



Notes

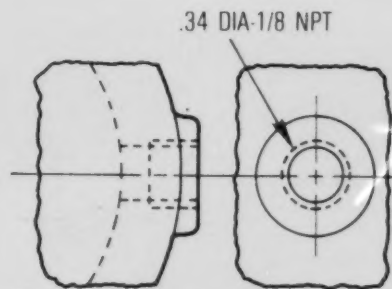
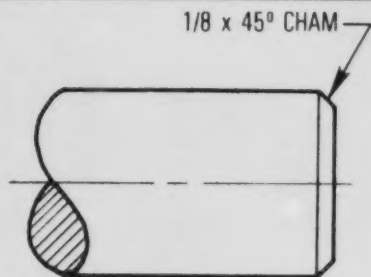
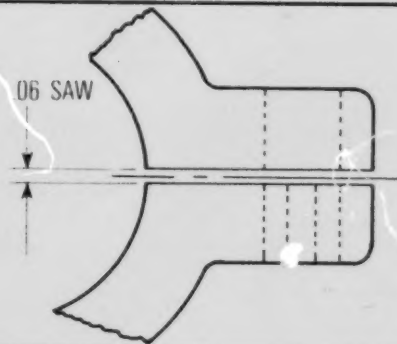
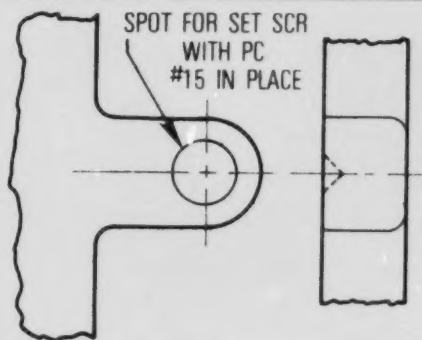
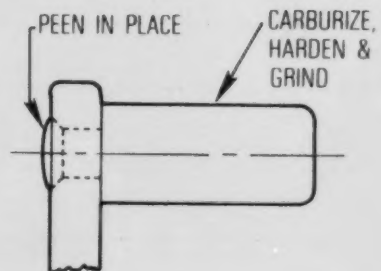
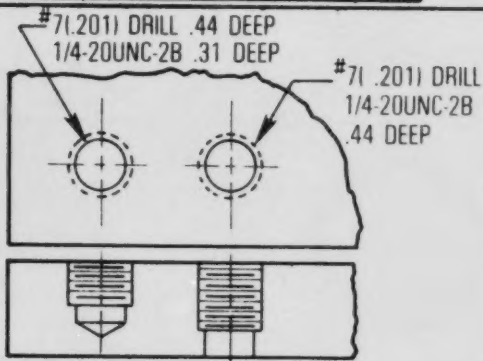
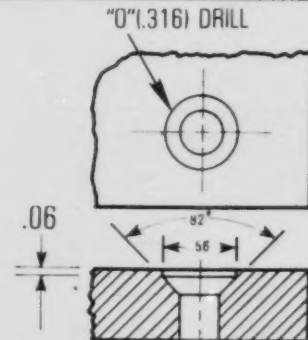
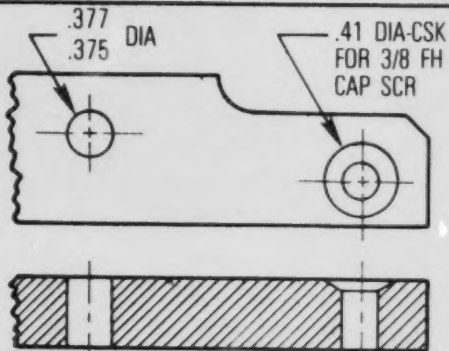
Notes are used to supplement the direct dimensions. They are brief, sometimes abbreviated or containing symbols, and are carefully worded to provide only one interpretation. Notes are classified into general notes and local notes.

General notes are located in the title block. Above or to the left of the title block or below the view to which they apply. See Figure below.

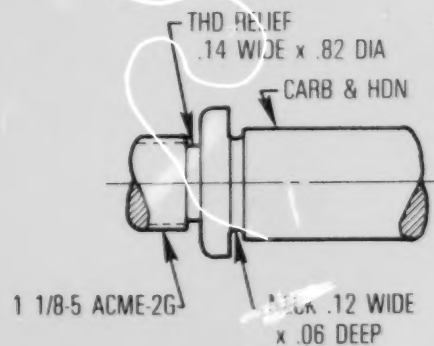
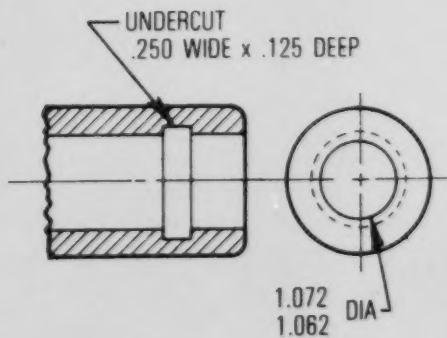
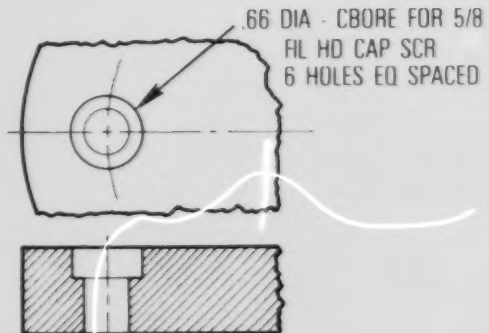
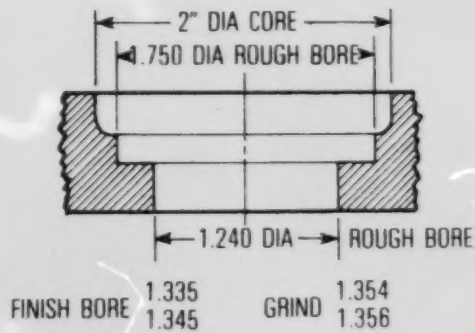
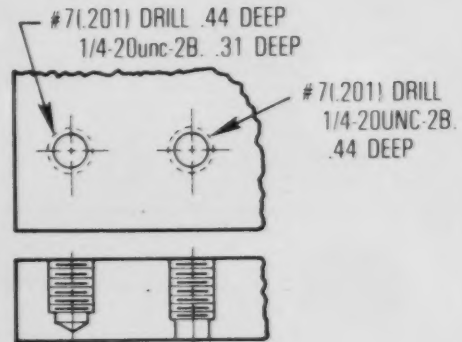
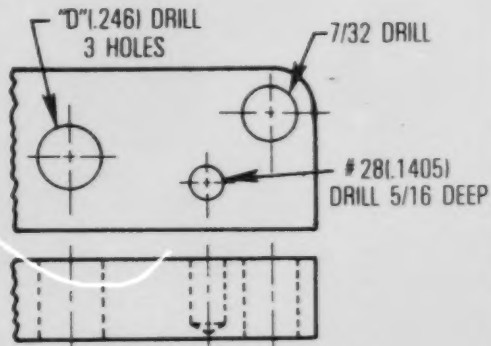
				QTY.	ORDER NO.		DWG. BY	CK. BY	APP. BY
NO.	CHANGE	DATE	BY	12	V-627	8/1/82	SCALE: 1=1	MAT. SAE 3140	L.R.
UNLESS OTHERWISE SPECIFIED:						LOWER DRUM SHAFT			
limits on decimal dimensions within $\pm .005''$						FINISH: FINISH ALL OVER BREAK ALL SHARP EDGES			A-121
limits on fractional dimensions within $\pm 1/64''$									
limits on angular dimensions within $\pm 1/2^\circ$									

Local notes apply to specific operations and are connected with a leader line to the point at which such operation is performed. Abbreviations are frequently used. In the following figures are examples of common local notes that are used on drawings.

LOCAL NOTES

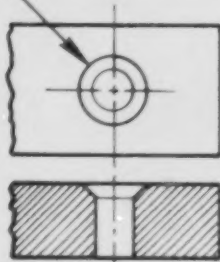


LOCAL NOTES

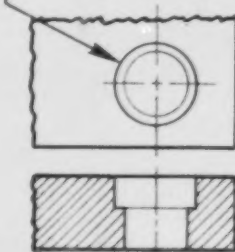


LOCAL NOTES

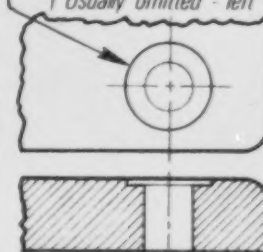
1/4" .2661 DRILL 82° CSK .56 DIA



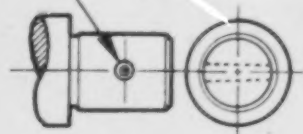
.66 DIA - .91 CBORE
.42 DEEP - 3 HOLES



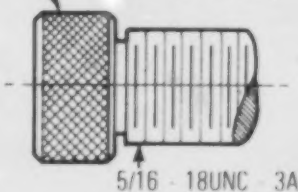
.34 DIA - 1 3/8 SPACE
.06 DEEP - 4 HOLES
(Usually omitted - left to stop)



.25 DIA - REAM FOR
#5 TAPER PIN WITH
PC #4 IN PLACE

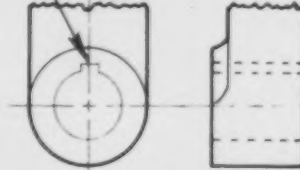


96 DP DIAMOND
KNURL - 30° RAISED



5/16 - 18UNC - 3A

KEYWAY
250 WIDE x .125 DEEP



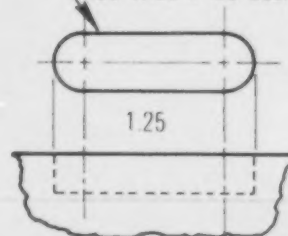
#808 AMER STD
WOODRUFF KEYSEAT



BROACH FOR
#808 AMER STD
WOODRUFF KEY



KEYSEAT
.38 WIDE x .38 DEEP



ASSIGNMENT SHEET
ON
ABBREVIATIONS, NOTES, AND SYMBOLS

II-B-3a(AS)

NAME _____

DATE _____

DIRECTIONS: Fill in the blank with that term that will correspond to the given abbreviation, symbol, or note.

EXAMPLE: 1. A.I.S.I.

1. American Institute of Iron
and Steel

1. ANG

1. _____

2. ϕ

2. _____

3. DP

3. _____

4. FPM

4. _____

5. RMS

5. _____

6. Typ

6. _____

7. FIR

7. _____

8. HSS

8. _____

9. NTS

9. _____

10. CHAM

10. _____

11. ID

11. _____

12. TPF

12. _____

13. F.A.O.

13. _____

14. P

14. _____

15. Sym

15. _____

16. WDF

16. _____

17. C'Bore

17. _____

18. OD

18. _____

19. BRO
20. CDS
21. BC
22. TOL
23. D
24. UNC
25. C'Sink
26. $\sqrt{I}$
27. π
28. $\sqrt{II}$
29. ϕ
30. $\frac{69}{\sqrt{}}$

In the following note 3/8 - 16 - UNC - 2A:

31. 3/8
32. 16
33. UNC
34. 2
35. A

19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____
31. _____
32. _____
33. _____
34. _____
35. _____

MATCHING TEST
ON
DIMENSIONS, NOTES, AND ABBREVIATIONS

II-B-3(T)
p. 1 of 2

NAME _____

DATE _____

DIRECTIONS: One item from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: B 1. Non-control finish mark

- A. Note
- B.
- C. Limit

Column I

Column II

- ___ 1. Bolt circle
- ___ 2. Brinell hardness number
- ___ 3. π
- ___ 4. Total indicator reading
- ___ 5. Finish all over
- ___ 6. 
- ___ 7. Class two-external thread
- ___ 8. Lay of surface
- ___ 9. Used to measure surface finish
- ___ 10. Term for reference edge
- ___ 11. Center line
- ___ 12. Permissible variation in size
- ___ 13. Diametral pitch
- ___ 14. Ratio
- ___ 15. Cast iron
- ___ 16. Unified national fine
- ___ 17. Angle
- ___ 18. Casting
- ___ 19. Heat treat
- ___ 20. Root mean square

- A. CI
- B. 
- C. 
- D. CSTG
- E. BC
- F. 
- G. Datum plane
- H. BH
- I. 3.1416
- J. RMS
- K. HT TR
- L. 2A
- M. TIR
- N. UNF
- O. FAO
- P. 63 Microinch finish
- Q. Tolerance
- R. :
- S. DP
- T. Profilometer
- U. Limit

SIMPLE RECALL TEST
ON
DIMENSIONS, NOTES, AND SYMBOLS

II-B-3(T)
p. 2 of 2

NAME _____

DATE _____

DIRECTIONS: Read each statement carefully. When the answer has been selected which will complete the statement correctly, place the answer in the corresponding blank space in the right hand column.

EXAMPLE: 1. A prism is one type of _____ geometric figure. _____

1. Holes are located with reference to their _____. _____
2. Location dimensions _____ surfaces with respect to each other. _____
3. The normal tolerance for a fractional dimension is _____. _____
4. Angles are measured in _____, minutes and seconds. _____
5. The note $\frac{1}{2}$ drill - 2 holes - $\frac{3}{4}$ " deep is classified as a _____ note. _____
6. The lower limit of $2.375 \pm .002$ is _____. _____
7. A reference edge is commonly referred to as a/an _____. _____
8. A dimension giving the diameter of a hole is a _____ dimension. _____
9. A drawing whose scale is $1" = 2"$ is _____ than its actual size. _____
10. The fractional size of the dimension $3.06"$ is _____. _____
11. The largest size an angle whose dimension is given $30^\circ \pm \frac{1}{2}^\circ$ is _____. _____
12. The most common method of representing a thread on a drawing is the _____ method. _____
13. In the thread note $5/8 - 18 - \text{UNF} - 2\text{B}$, the 18 represents the _____. _____
14. The term "_____ " surface refers to surfaces that have material removed. _____
15. The _____ of a surface finish indicates the direction of the machine tools marks. _____

INFORMATION SHEET
ON
PRINT READING

II-B-4(IS)

SUBJECT: Sectional Views

INTRODUCTORY
INFORMATION:

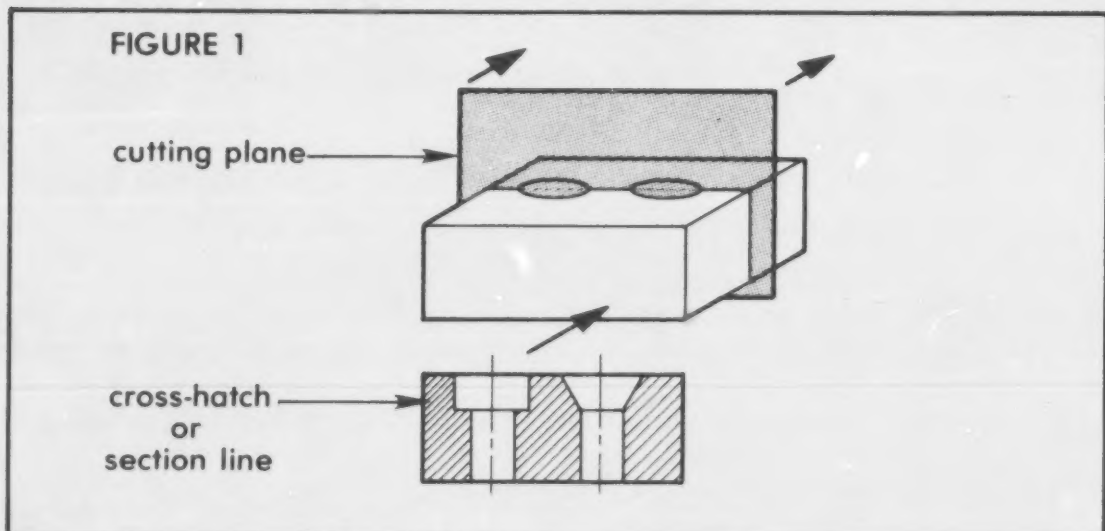
Frequently the interior of an object is so complicated that the customary method of showing hidden features with dashed lines is confusing and almost impossible to read. In cases such as this, and where parts are shown in assembly or where some detail of the shape of the object is not clear, an auxiliary (helping) view is used. This auxiliary view is called a sectional view. Sectioned views assist in the clarification of: interior parts; assembly of different parts or materials; description of irregular shapes; and dimensioning purposes.

Understanding the principles of sectioning and of the various types is vital to the worker's ability to read and interpret prints that are common to the machinist.

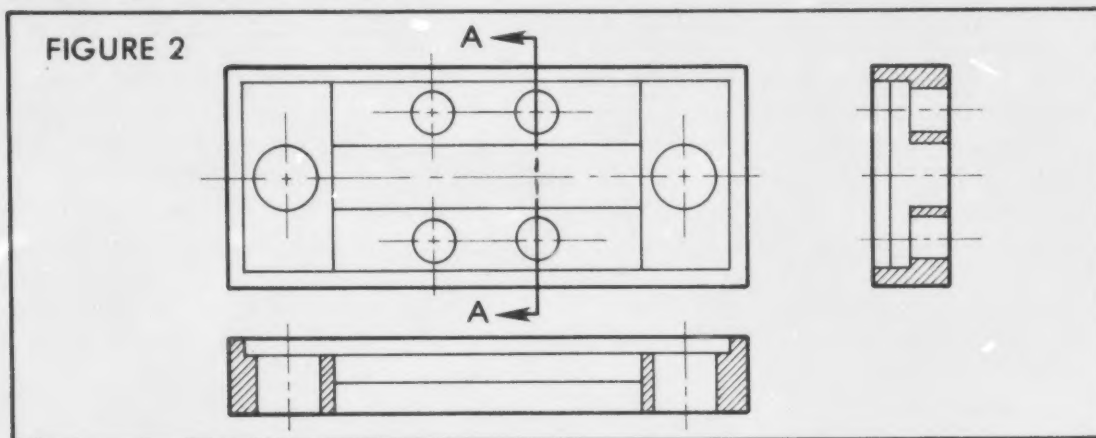
GENERAL INFORMATION

Principle of Sectioning

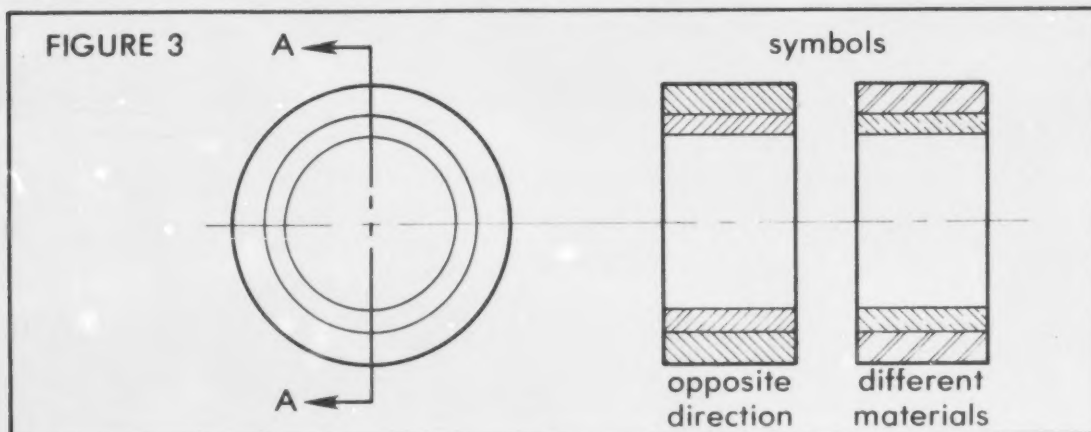
In sectioning, the object is cut by an imaginary plane called the cutting plane, which cuts the object in two, in much the same manner as cutting into an apple and removing a portion. A view of the cutaway part is drawn showing portions of the object that are solid and those that are voids or spaces. The solids are shown by section lining or "cross-hatching" and the spaces or voids are left blank. All edges exposed are shown as visible edges, as in Figure 1.



The place from which the section is taken must be identifiable on the drawing in a principal view, and the solids and voids must be distinguished on the sectional view. In many cases the place from which the section is taken is obvious and a cutting plane is not required. Such is the case where sections are quite evidently taken through the center as indicated by the center line. If the place from which the section is taken is not obvious, then the cutting plane with directional arrows and identification letters are shown, as in Figure 2. The cutting plane A-A is shown because the section might be taken elsewhere.



The solids of the section are section lined or "cross-hatched" using the material symbol for cast iron which is used in all cases except where the type of material is to be shown or where two or more parts show in assembly, in which case the symbol for each material is shown or the direction of section lines are drawn in opposite directions. These two methods are illustrated in Figure 3.

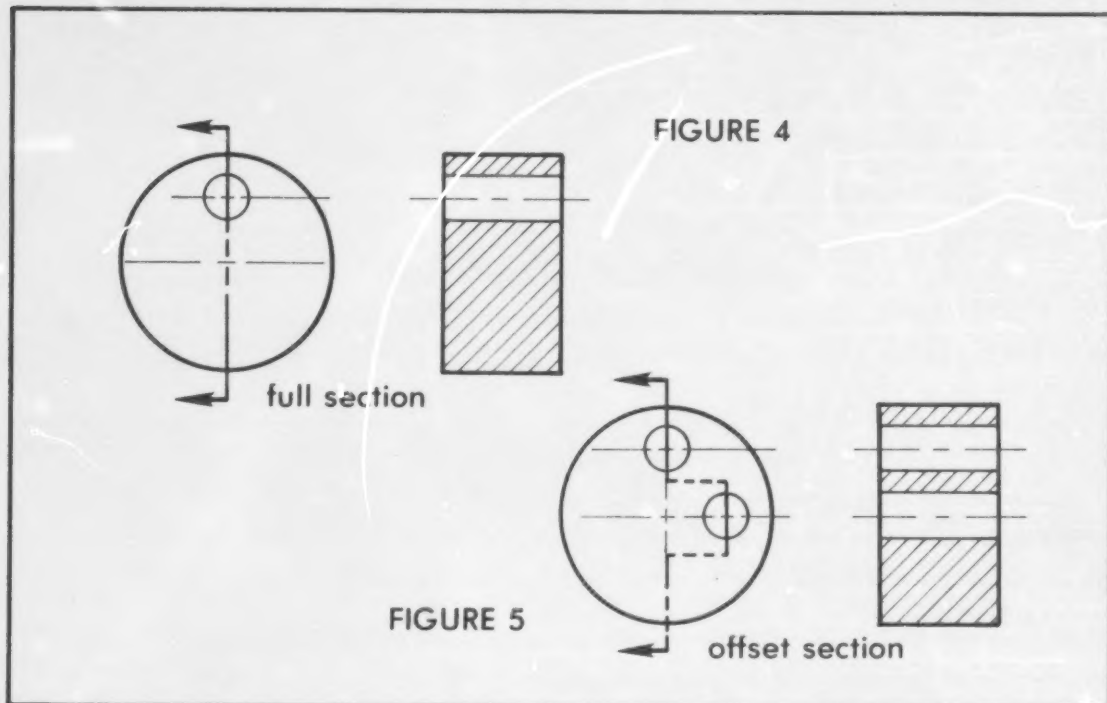


Although there are different types of sections, and the sectional views have been named for identification and specifying the type of view required in a drawing, the names are not shown on the drawing as the views are easily interpreted and the worker does not require the name to read the drawing. The sectional names are assigned by the character of the section or the amount of the view in section, and based upon the information to be conveyed and design of the object.

Although there are many techniques in sectioning there are four major types; namely: full section, half section, revolved section, and broken out section. From these basic four, additional techniques are used for specific sectioning purposes.

Full Section

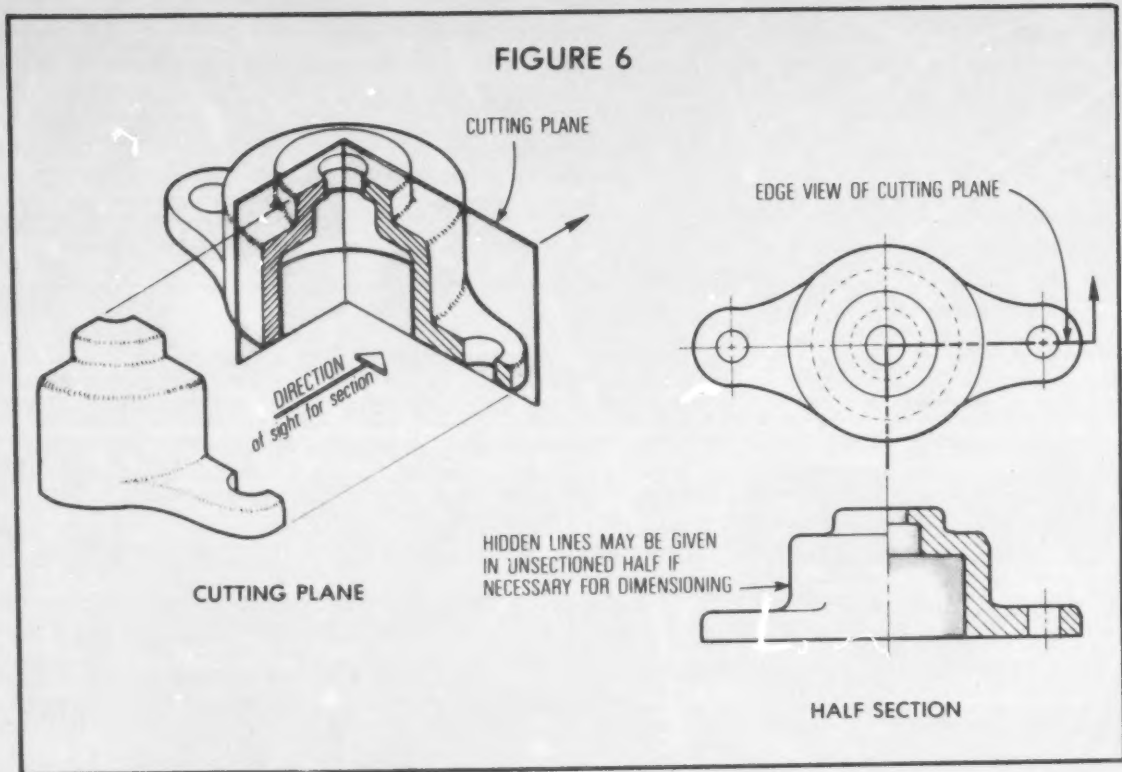
The full section is one in which the cutting plane passes entirely across the object cutting it into two pieces, as in Figure 4. The full section cutting plane line does



not necessarily have to follow one direction only. In sectioning through irregular objects it may be desirable to include features that do not lie in a straight line. By bending or "offsetting" the cutting plane, as in Figure 5, the cutting plane picks up both holes. This type of full section is called an offset section. The cutting plane line of an offset section always changes direction at right angles but is not shown in the sectional view.

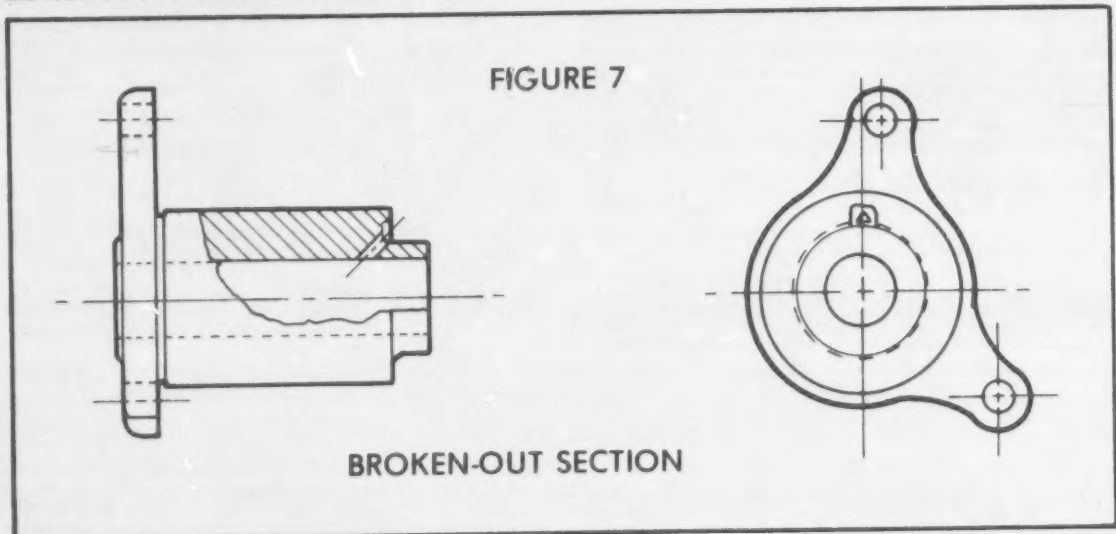
Half Sections

On parts that are symmetrical, interior details can be fully described by passing the cutting plane only halfway through the object, thereby removing only one-fourth of the object. The result is a half section, Figure 6. A half section has the advantage of exposing the interior of one-half the object and retaining the exterior of the other half. The greatest usefulness of the half section is in assembly drawing, in which it is often necessary to show both internal and external construction on the same view without dimensions. In half section drawings, a center line is used to separate the sectioned half from the unsectioned half, although a visible line may be used.



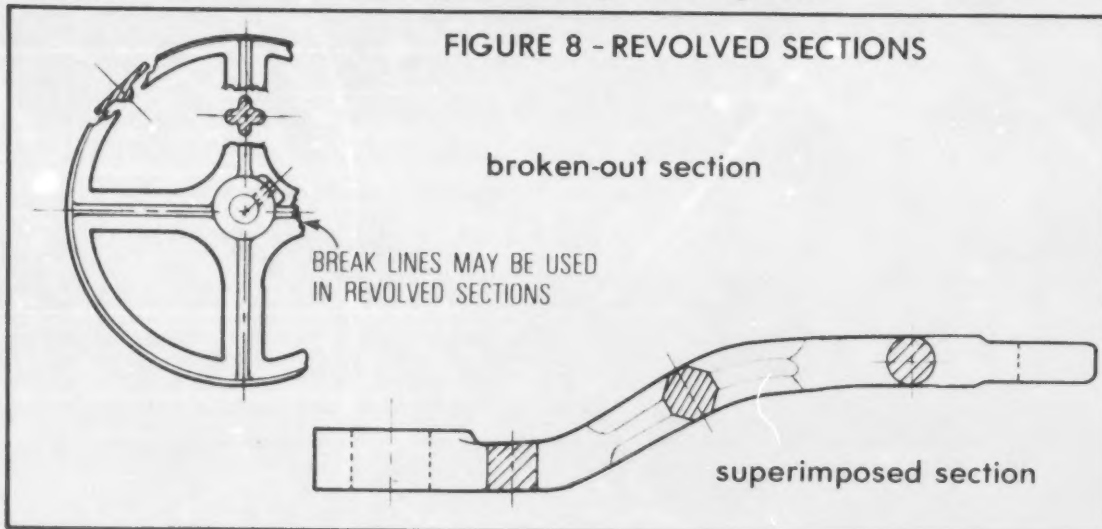
Broken-Out Section

Often an interior portion must be shown, but to use a half section or full section would remove some feature that must be included. When this is the case, a partial section called a broken-out section it is assumed that the cutting plane passes through the feature even though the cutting plane is not drawn. A freehand break line is used instead and limits the sectioned area.



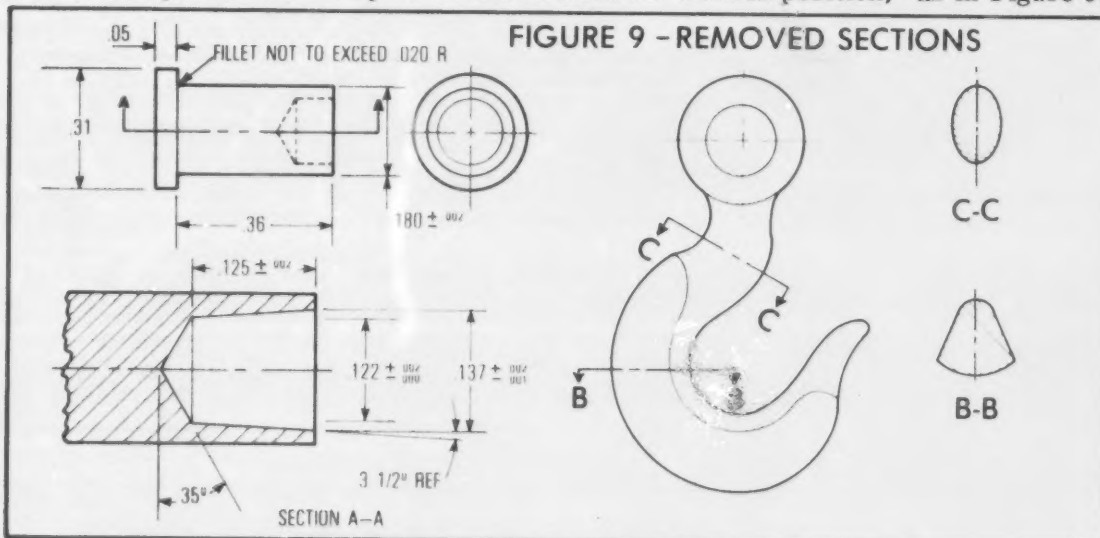
Revolved Section

A revolved section is used to describe the cross section of an object, such as a spoke, rib, bar, or other detail at a special point. Such sections are made by assuming a plane perpendicular to the center line or axis of the bar or other object, then revolving the plane through 90° about the center line at right angles to the axis. The visible lines adjacent to the revolved section may be "broken-out" or the superimposition of the revolved section on the original drawing, as in Figure 8.



Removed Section

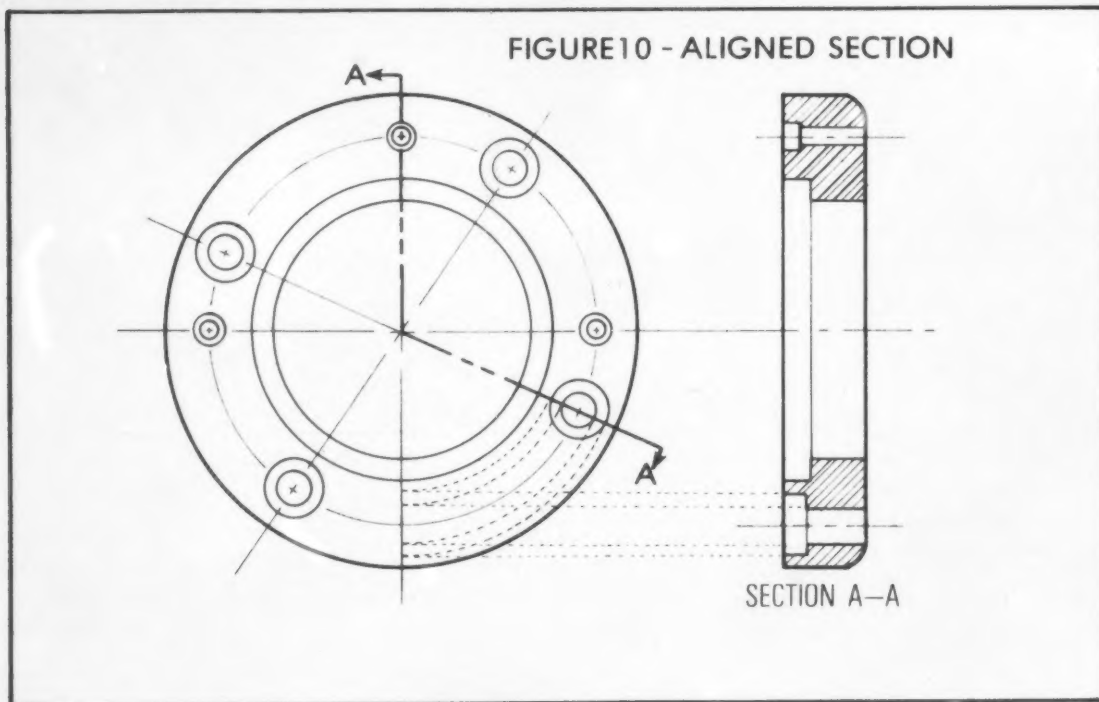
Frequently, as a means of clarifying the shape of an object or showing dimensions more clearly, a section may be removed from its normal position, as in Figure 9.



Removed sections are labeled to correspond to the letters at the end of the cutting plane line, such as section A-A, B-B, and C-C. In some cases it may be necessary to show a removed section on another sheet. In these cases a cross-reference is given, such as: Section B-B on sheet 2.

Aligned Sections (angular sections)

The aligned section is a type of full section, whereby the cutting plane line is bent to include certain elements, such as holes that are not located on either the vertical or horizontal axis, and revolves these elements onto a vertical position (aligned), from where it is projected to the sectional view, as in Figure 10. By aligning the hole, the sectional view gives a clearer and more complete description than if it were projected in its true position.



ASSIGNMENT SHEET
ON
SECTIONING

II-B-4(AS)

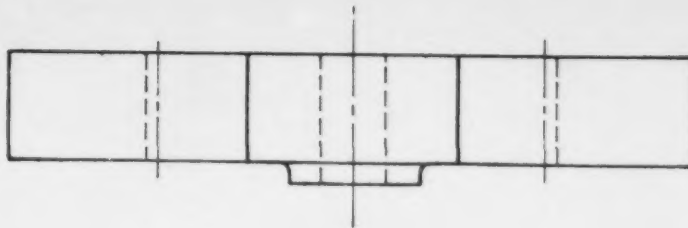
- SUBJECT:** Complete Sectional View
- AIM:** The student will be able to complete the sectional view of a given object with the specified material symbol and identify the type of sectional view.
- INTRODUCTORY INFORMATION:** Frequently the machinist is exposed to drawings that have complicated interior parts that require a more clear method of describing the interior. By using a sectioned view, the interior or a special section of the drawing is exposed so as to view the interior more clearly. Information contained in this assignment will provide the student with the knowledge required to read and interpret a sectioned view, to visualize the interior of an object, and to properly section the part with required material symbol.
- REFERENCE:** Information Sheet II-B-4(IS) "Sectional Views"
- QUESTIONS OR PROBLEMS:** Assignment Sheet II0B-4(AS) consists of six problems. Each problem is a multi-view drawing with a cutting plane shown in one view. The student is to complete each drawing by completing the sectioned view with the necessary lines and by sectioning lining the view with the specified material symbol.

SECTIONING EXERCISE #1

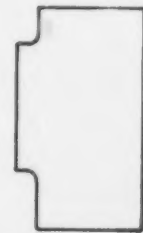
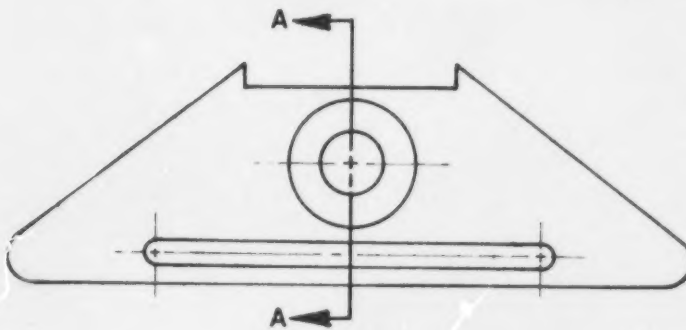
Name: _____

II-B-4(AS)

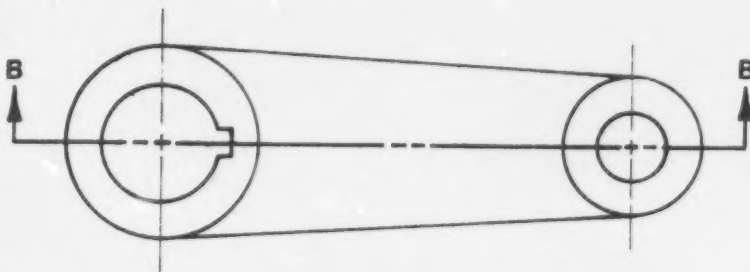
Date: _____



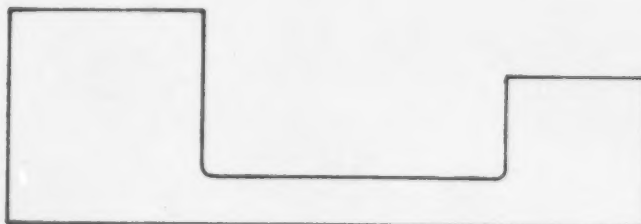
MAT'L: BRASS



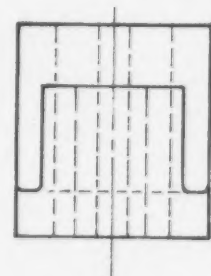
SECTION A-A



MAT'L: STEEL



SECTION B-B



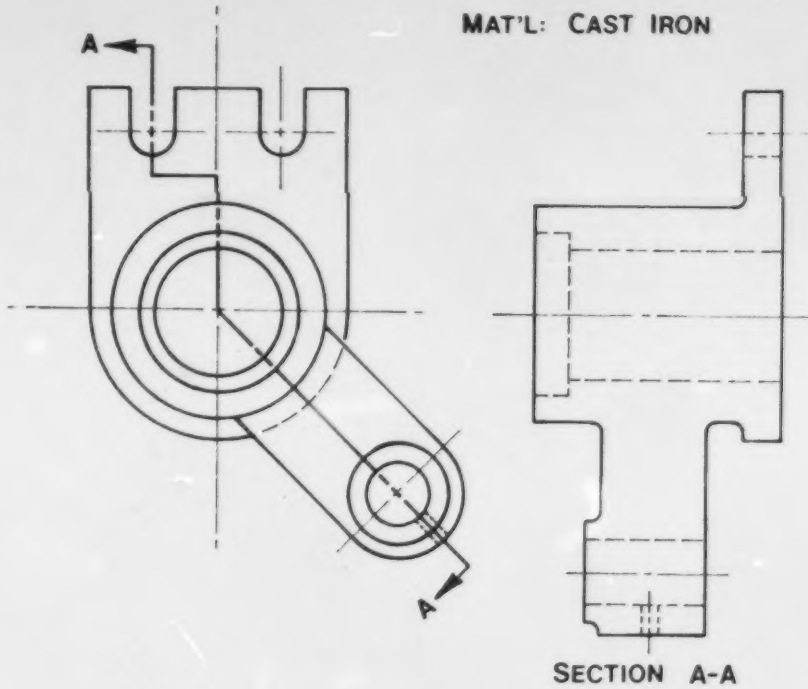
SECTIONING EXERCISE #3

Name: _____

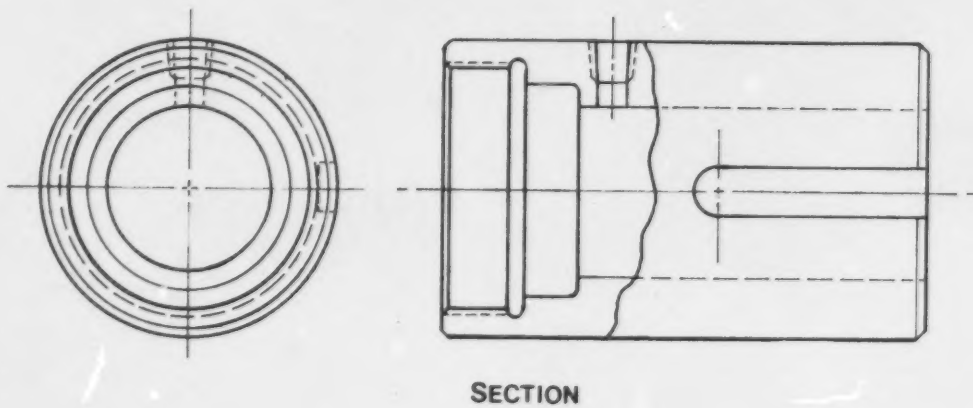
II-B-4(AS)

Date: _____

MAT'L: CAST IRON



MAT'L: BRASS



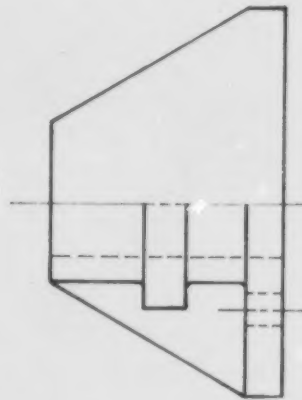
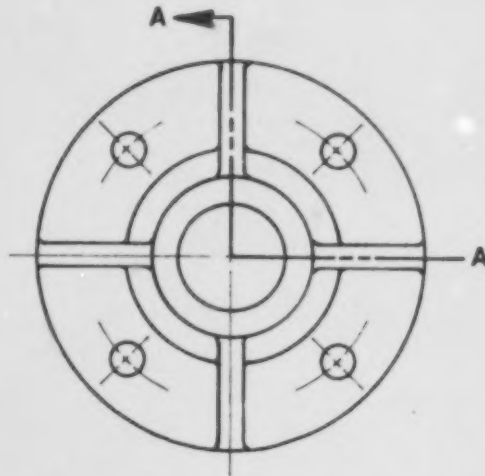
SECTIONING EXERCISE #2

Name: _____

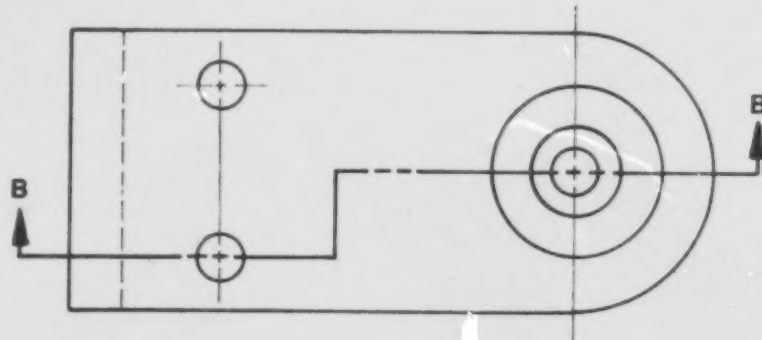
II-B-4(AS)

Date: _____

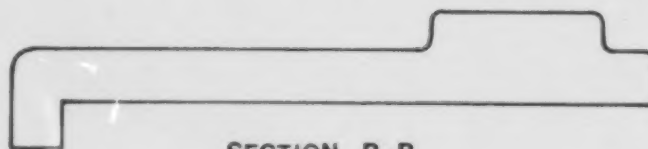
MAT'L: CAST IRON



SECTION A-A



MAT'L: ALUMINUM



SECTION B-B

ASSIGNMENT SHEET
ON
SECTIONING

II-B-4a(AS)

- SUBJECT:** Read A Sectioned Print
- AIM:** The student will be able to read and interpret a sectioned print by studying the print and recording specific information required in the manufacturing of the part.
- INTRODUCTORY INFORMATION:** One of the valuable functions of sectioning is to provide a clear method of dimensioning internal parts. The practice of dimensioning to hidden lines creates confusion in relating the dimension to the part that is dimensioned. The clearer that a dimensioned part can be shown, the easier it is for the machinist to interpret the drawing and locate each dimension. This reduces the time lost in trying to interpret the drawing, thereby reducing manufacturing cost. This assignment will assist the student in the reading of prints more quickly and accurately.
- REFERENCE:** Information Sheet II-B-4(IS) "Sectioned Views"
- QUESTIONS OR PROBLEMS:** In Assignment Sheet II-B-4a(AS) the student will carefully study the print and record the correct answer in the blank corresponding to the given term or statement.

ASSIGNMENT SHEET
ON
SECTIONING

II-B-4a(AS)
#1

NAME _____

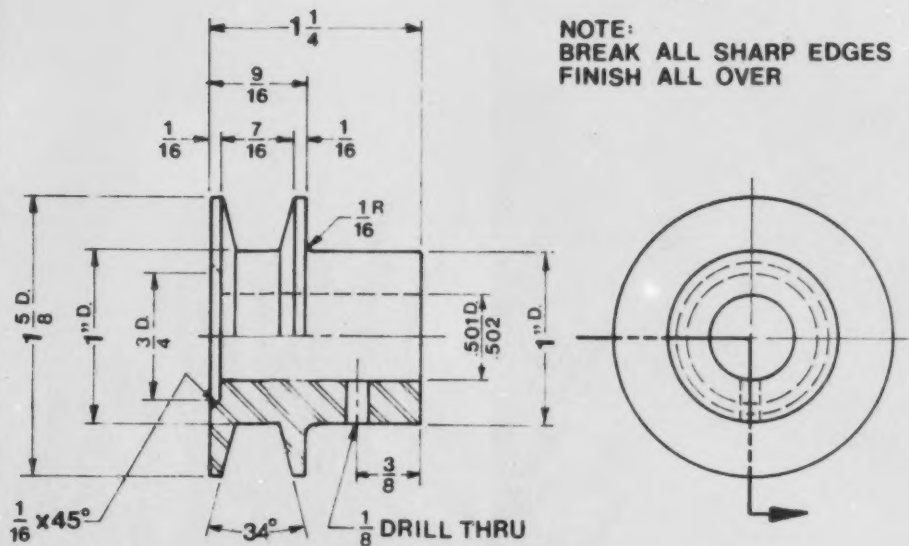
DATE _____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE: 1. Print Number

C-171

1. Material
2. Largest pulley diameter
3. Oil hole size
4. Maximum shaft hole size
5. Smallest pulley diameter
6. Vee groove angle
7. Oil hole location from end of hub
8. Fillet size between pulley and hub
9. Type section
10. Pulley shaft diameter
11. Vee groove greatest width
12. Length of hub
13. Depth of pulley recess
14. Pulley recess diameter
15. Maximum allowable groove angle
16. Name of part
17. Minimum shaft hole size
18. Fractional dimension limits
19. Treatment of edges
20. Pulley width



MAT'L: 4140 H.R.S.
H.T. 38-42 R/C

TOLERANCES UNLESS OTHERWISE NOTED	SCHOOL OR COMPANY		
	ADDRESS		CITY, STATE
FRACTIONS $\pm 1/64$	V BELT PULLEY		
DECIMALS $\pm .005$			
ANGLES $\pm 1.4^\circ$	DWN BY	DATE	DWG. NO.
FINISHES $\sqrt{25}$	CKD BY	SCALE	C-171
			SHT. OF

ASSIGNMENT SHEET
ON
SECTIONING

II-B-4a(AS)
#2

NAME _____

DATE _____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

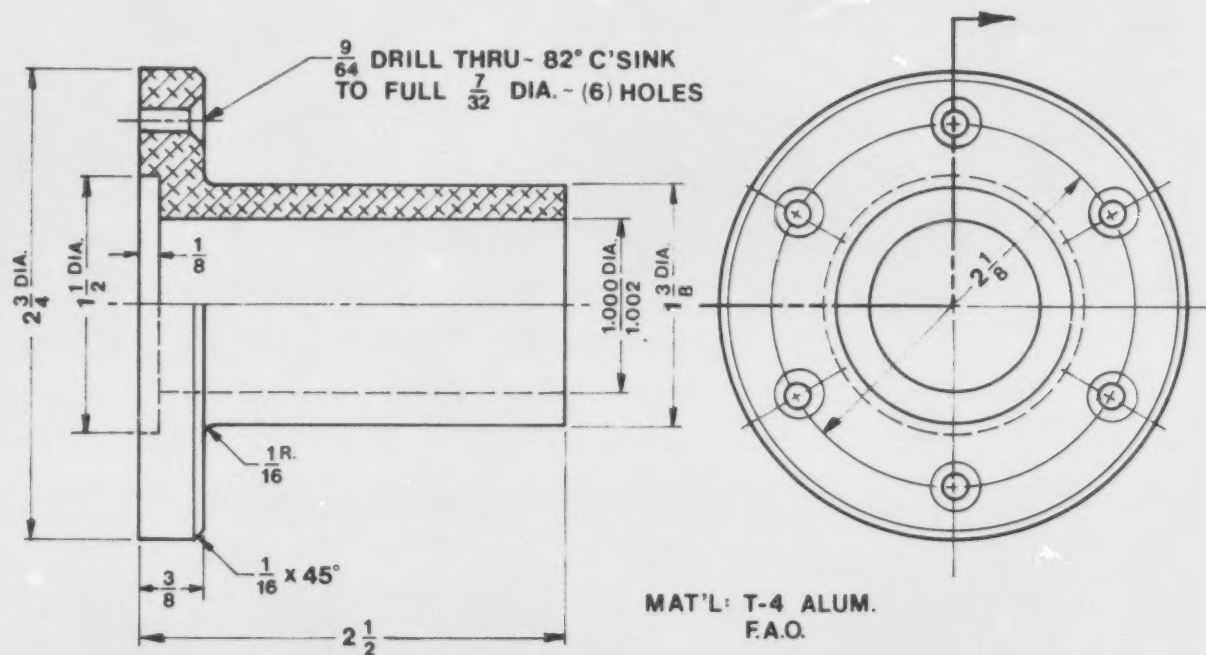
EXAMPLE:

1. Print Number

C-111

1. Part name
2. Minimum bore diameter
3. Material
4. Bolt circle diameter
5. Diameter of counter bore
6. Hub length
7. Type finish specified
8. Outside diameter of hub
9. Largest diameter (flange)
10. Angle spacing of holes
11. Depth of counter bore
12. Flange thickness
13. Fraction tolerance permitted
14. Decimal tolerance permitted
15. Largest bore diameter
16. Number of drilled holes
17. Type section
18. Radius between hub and flange
19. Size flange chamfer
20. Operations performed on screw holes

C-111



TOLERANCES UNLESS OTHERWISE NOTED	SCHOOL OR COMPANY		
	ADDRESS		CITY, STATE
FRACTIONS ± 1/64	CAM CARRIER SUPPORT		
DECIMALS ± .005	DWN BY	DATE	DWG NO.
ANGLES + 1/4°	CKD BY	SCALE	C-111
FINISHES 125✓			SHEET OF

SIMPLE RECALL
ON
SECTIONAL VIEWS

II-B-4(T)
p. 1 of 2

NAME _____

DATE _____

DIRECTIONS: Read each statement carefully. When the answer has been selected which will complete the statement correctly, place the answer in the corresponding blank space in the right hand column.

EXAMPLE: 1. The symbol for general use of all material is ____.

_____ cast iron

1. Half sections are commonly used for objects that are ____ in shape.
2. In a ____ section the cutting plane is assumed perpendicular to the center or axis of the object and rotated 90°.
3. The arrowheads on a cutting plane line give the direction of ____ of the viewer.
4. The removed section of an object is identified by ____.
5. On broken-out sections, the limits of the section are shown by a ____ line.
6. In a sectional view, solid portions of the object cut by the cutting plane are section lined or ____.
7. In an assembly section the section lines may show different types of ____ or drawn in opposite directions.
8. To show features that do not lie in a straight line, the cutting plane is bent at 90° angles to form a/an ____ section.
9. A ____ section is used to dimension parts that are too small to do so on the original drawing.
10. Holes on a flange that do not lie on either the vertical or horizontal axis are shown by use of a/an ____ section.

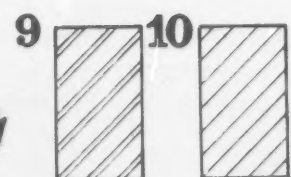
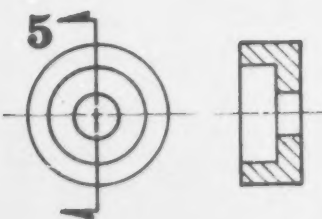
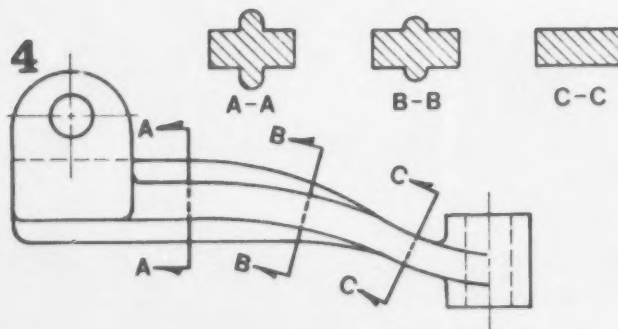
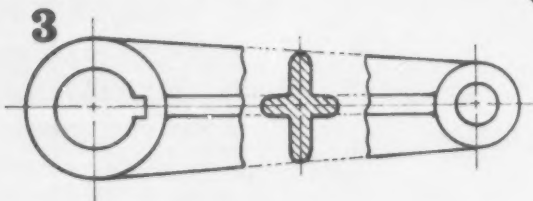
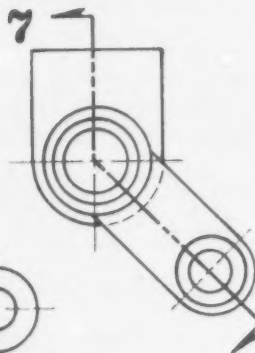
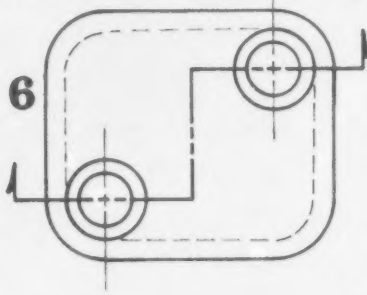
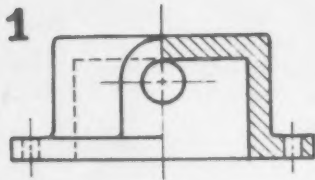
PICTORIAL RECALL TEST
ON
SECTIONAL VIEWS

II-B-4(T)
p. 2 of 2

NAME _____

DATE _____

DIRECTIONS: Below are different types of sectional views or procedures and sectioning symbols. Identify each and write the answer in the corresponding numbered blank space provided for in the right hand column.



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

INFORMATION SHEET
ON
PRINT READING

II-B-5(IS)

SUBJECT: Auxiliary Views

INTRODUCTORY
INFORMATION:

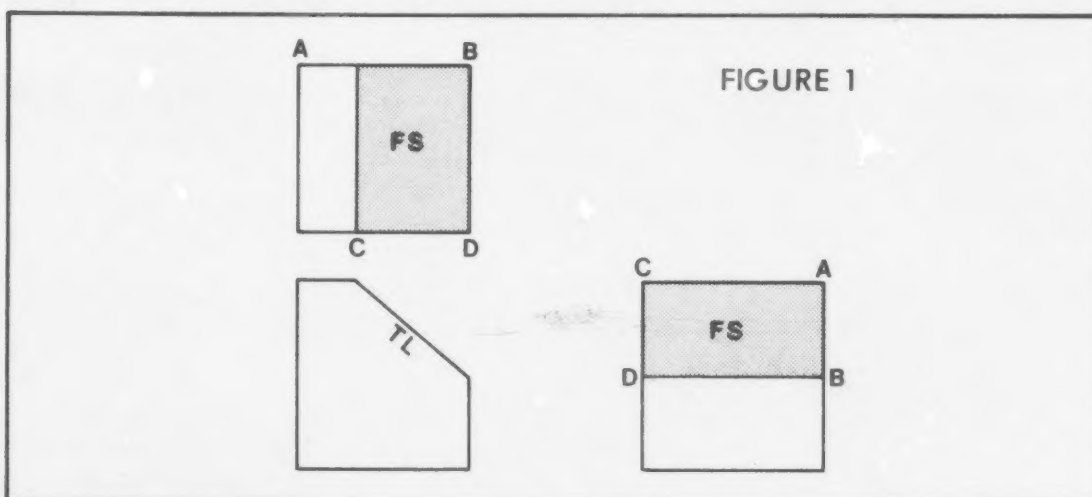
The word auxiliary derives from the Greek word auxein, which means to increase or help. In drawing the function of an auxiliary view is to provide assistance by helping to increase the clarity of a complicated drawing.

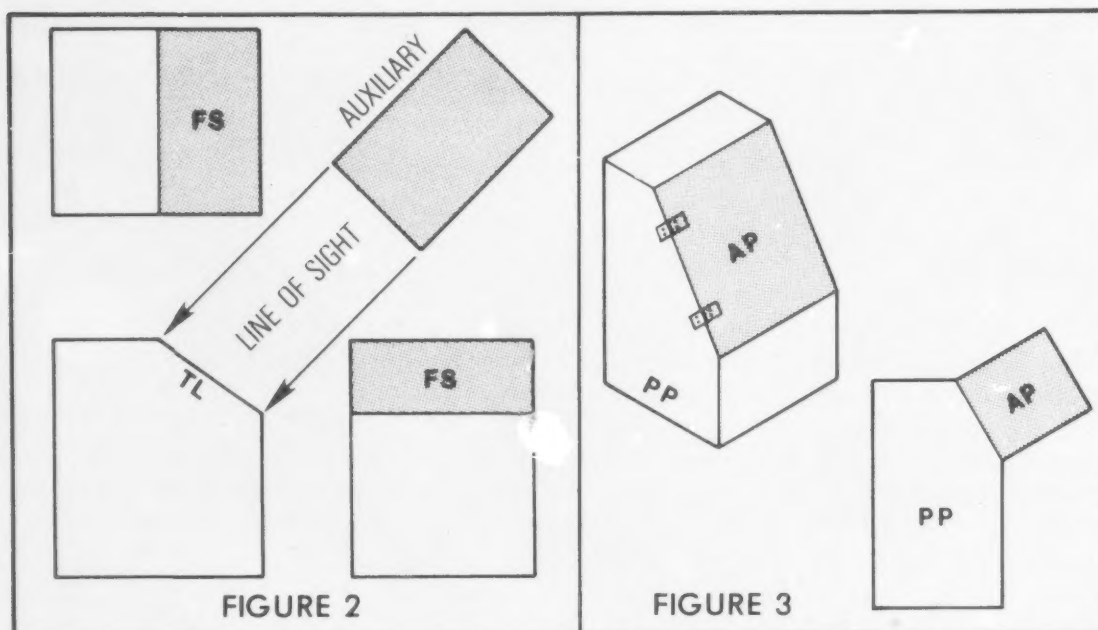
Many parts have surfaces that are not parallel with the regular planes of projection, thereby causing the surface to be view distorted. This makes reading and interpretation difficult, as the surface cannot be viewed accurately or dimensioned by conventional methods.

GENERAL INFORMATION

Principle of Auxiliary Views

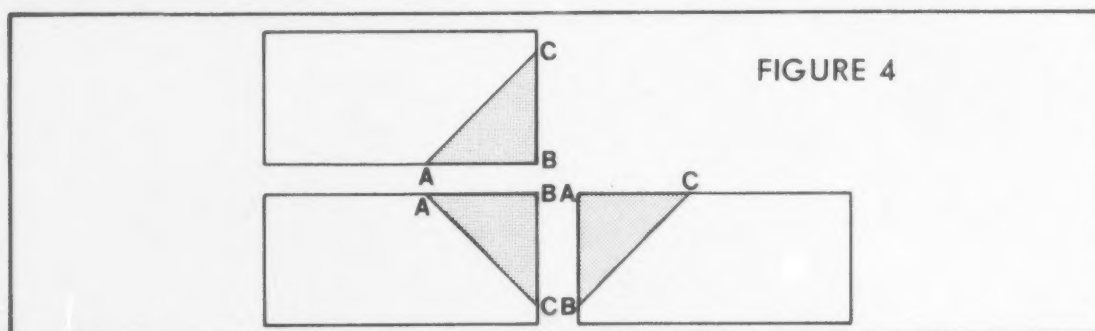
As previously stated, some objects have slanted surfaces which cannot be clearly shown by means of conventional views. These slanted surfaces may be either inclined or oblique. An inclined surface is one that is at an angle with two regular planes of projection, but is perpendicular to the third. As in Figure 1, surface ABCD is viewed foreshortened (FS) in the top and right side views. In the front view, the surface is perpendicular to the frontal plane and seen as a true length edge (TL). To view the surface in true shape, a special view known as an auxiliary view is needed. This view is one that simply shows the outline of the surface as it appears to the observer when looking directly at the surface, as in Figure 2.





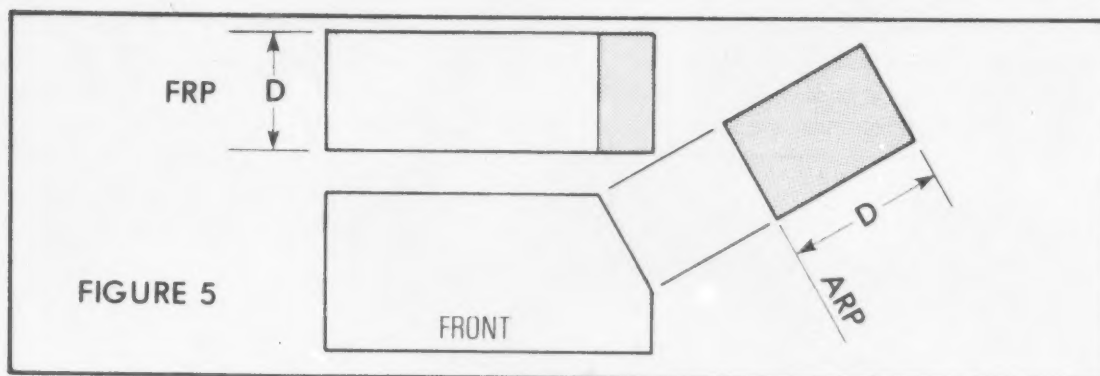
In an auxiliary view it is assumed that the slanted surface is hinged to one of the principal planes (PP) and when revolved flush with the principal plane it becomes parallel to the slanted edge, as in Figure 3, thereby showing the surface in true shape. This auxiliary view is referred to as a Primary Auxiliary View.

The oblique (skewed) surface is inclined to all regular planes of projection, and therefore is viewed as a foreshortened (FS) edge in all regular views, as surface ABC is in Figure 4. These surfaces are in such a position that they cannot be shown in true size by projecting them upon normal planes or primary auxiliary planes. In cases such as this, a secondary auxiliary is projected off a primary auxiliary, much the same as in a primary view projection.

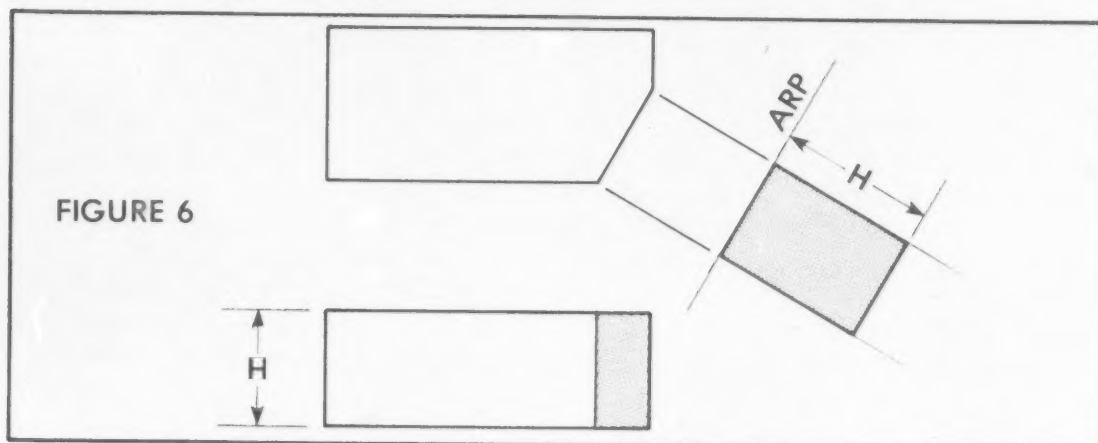


Classification of Auxiliary Views

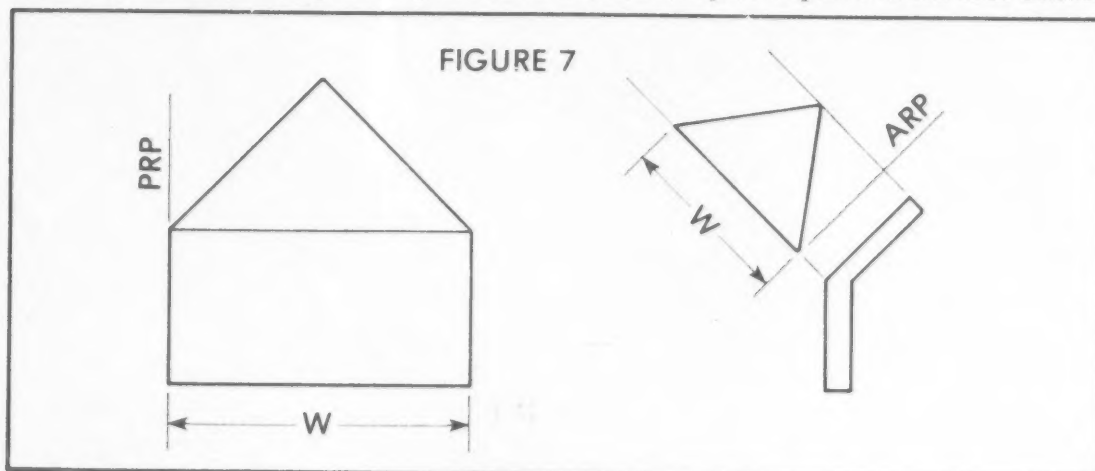
Auxiliary views are classified according to the position they assume when projected from the principal view and the principal dimension in the auxiliary view. In Figure 5, the auxiliary view is projected from the front view, and the principal dimension is depth. This is referred to as a depth auxiliary or front view projection.



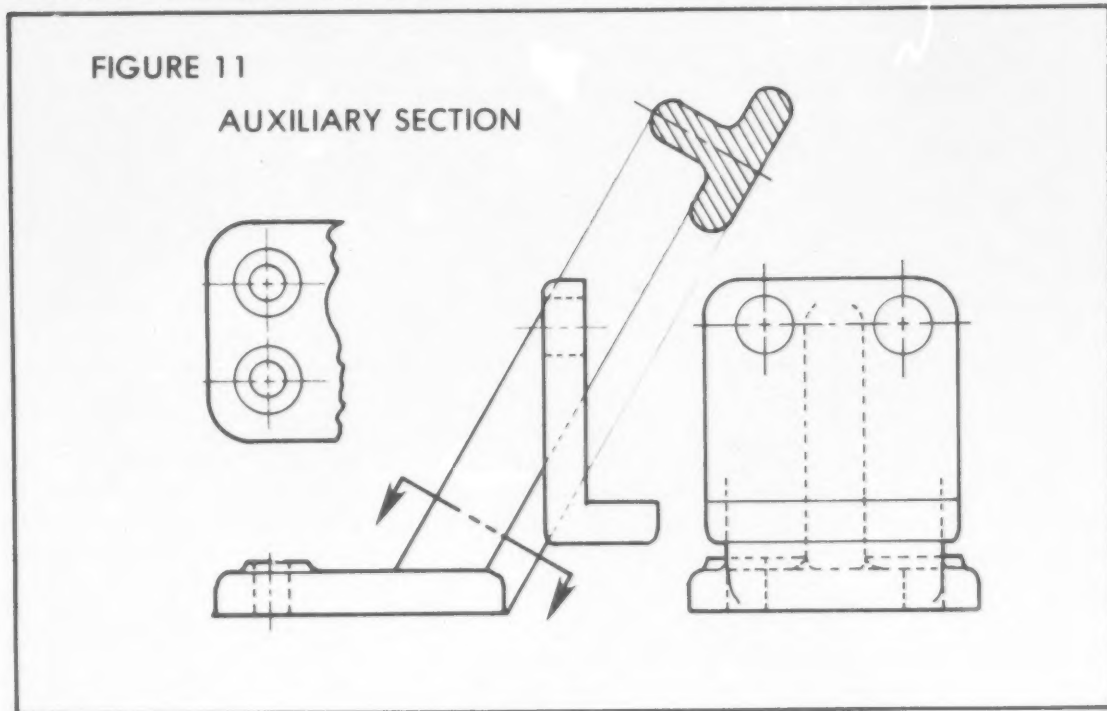
In Figure 6, the auxiliary view is from the top view, and the principal dimension is height which is taken from the front view. This type of auxiliary view is a top view projection or height auxiliary.



Likewise, a projection from the side view would be a width auxiliary or side view projection. See Figure 7. From this it can be concluded that the location of the auxiliary view depends upon the position in which the object is placed when it is drawn.



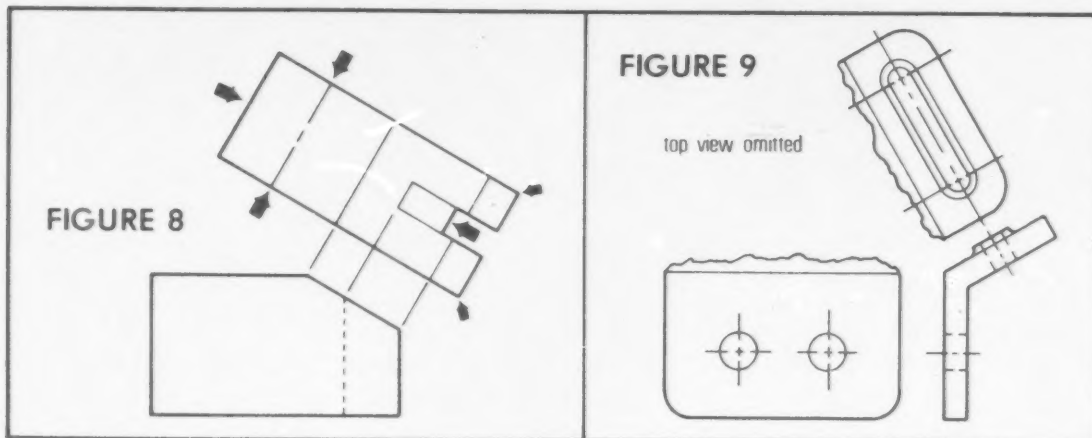
In parts that have cone surfaces, ribs, webs, or where a sectional view will clarify the drawing or aid in dimensioning, an auxiliary section is used, as shown in Figure 11. It is not uncommon to have the sectioned surface viewed alone, unless there is a need, such as for dimensioning purposes, to show the entire object behind it.



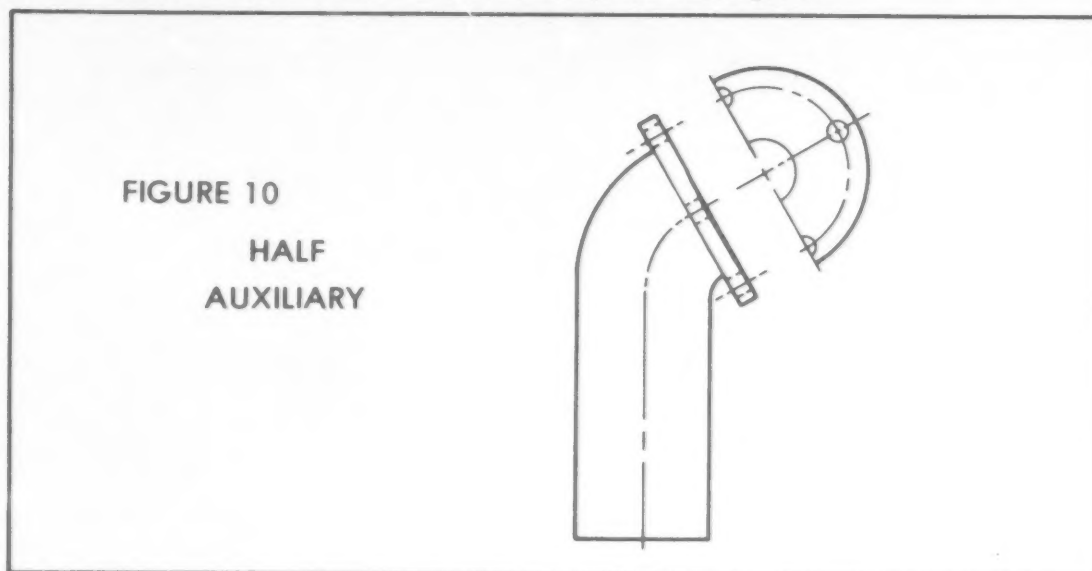
Types of Auxiliary Views

As a common rule, only the inclined surface of an object is shown and not the entire outline of the part. Since the primary purpose of an auxiliary view is to provide clarity in size and shape of an inclined surface, little would be gained by adding an auxiliary view with regular surfaces, as they would appear distorted.

The use of partial auxiliary views minimize confusing lines (Hidden lines are normally not shown) and improve the clarity of the view, as shown in Figure 8. In some cases, the need for a principal view is eliminated as illustrated in Figure 9, where the top view is omitted.



When an auxiliary view is symmetrical, only one-half of the view may be shown. As illustrated in Figure 10, the flanged fitting has only one-half presented since the other half is simply a duplication. This type of drawing is a half auxiliary view. The center line of the part is used as the auxiliary reference plane.



ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

II-B-5(AS)

SUBJECT: Auxiliary Views

AIM: The student will be able to read a print that includes the use of auxiliary views.

INTRODUCTORY INFORMATION: Auxiliary views are aids in visualizing an object because they carry out the principle of projecting a view of an object in its true shape. This permits a more accurate method of viewing and dimensioning inclined or oblique surfaces. This assignment will provide the student experience in reading prints that include auxiliary views.

REFERENCES: Information Sheet II-B-5(IS) "Auxiliary Views"

QUESTIONS OR PROBLEMS: In the following problems, II-B-5(AS) #1 and #2, the student will study the given views of the part carefully and record the correct answer in the blank corresponding to the given statement, symbol, or dimension letter (ex. dimension "J"). Dimensions of some parts may require calculating or referring to another view.

ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

II-B-5(AS)
#1

NAME _____

DATE _____

DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE:

1. Section Identification

A-A

- | | |
|---|-------|
| 1. Size of drilled holes | _____ |
| 2. Size of reamed hole | _____ |
| 3. Dimension "A" | _____ |
| 4. Inclined surface angle | _____ |
| 5. ✓ | _____ |
| 6. Dimension "J" | _____ |
| 7. Dimension "H" | _____ |
| 8. Dimension "L" | _____ |
| 9. Dimension "B" | _____ |
| 10. Type auxiliary | _____ |
| 11. Type material | _____ |
| 12. Fillet size | _____ |
| 13. Distance between drilled hole centers | _____ |
| 14. Dimension "G" | _____ |
| 15. Dimension "F" | _____ |
| 16. Dimension "M" | _____ |
| 17. Dimension "I" | _____ |
| 18. Dimension "C" | _____ |
| 19. Dimension "D" | _____ |
| 20. Thickness of inclined part | _____ |

ASSIGNMENT SHEET
ON
AUXILIARY VIEWS

II-B-5(AS)
#2

NAME _____

DATE _____

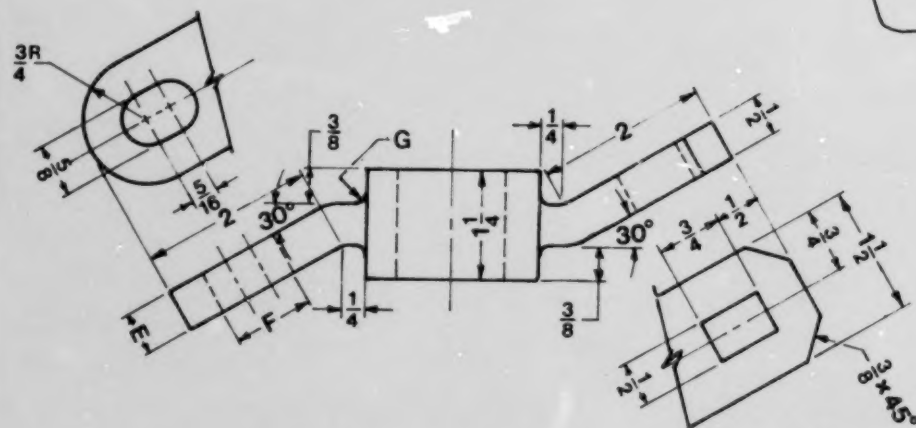
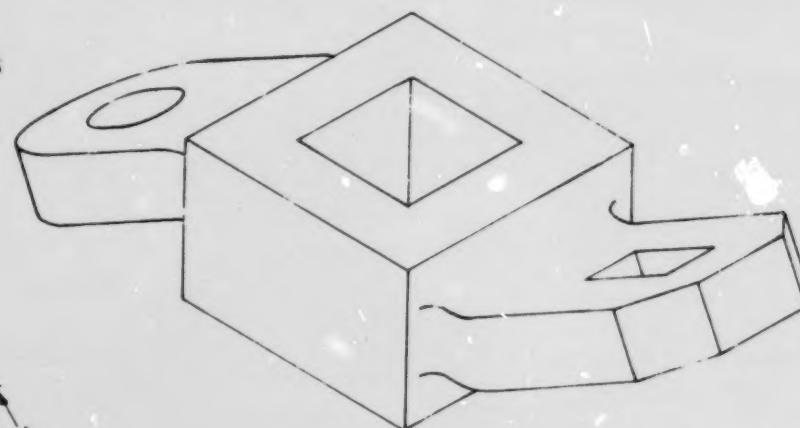
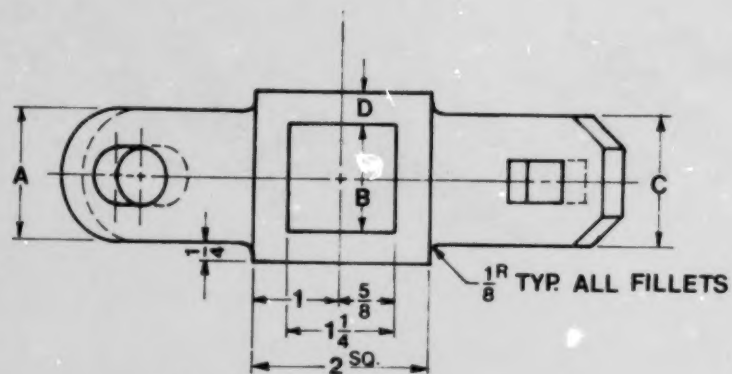
DIRECTIONS: Read and interpret the following print by recording the correct answer in the blank corresponding to the statement.

EXAMPLE:

1. Three Dimensional Drawing

pictorial

1. Size of square hole (top view)
2. Size of rectangular hole
3. Dimension "A"
4. Dimension "D"
5. Dimension "C"
6. Dimension "E"
7. Angle of arms
8. Dimension "G"
9. Radius dimension of rounded end
10. Fillet sizes
11. Size of chamfered corners
12. Height of center section



TOLERANCES UNLESS OTHERWISE NOTED			
FRACTIONS $\pm 1/64$			
DECIMALS $\pm .005$			
ANGLES $+ 1/4^\circ$	DWN BY	DATE	DWG. NO.
FINISHES $\sqrt{125}$	CKD BY	SCALE	SHT. OF

MATCHING TEST
ON
AUXILIARY VIEWS

II-B-5(T)

NAME _____

DATE _____

DIRECTIONS: One statement from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: A 1. A line not parallel to any regular plane of projection

A. Oblique

Column I

Column II

- ___ 1. Perpendicular to only one plane of projection
- ___ 2. Pierces auxiliary plane at right angle
- ___ 3. Projection of entire part
- ___ 4. Method of viewing symmetrical parts
- ___ 5. Ellipse in regular view
- ___ 6. Shows detail of only one part
- ___ 7. Eliminated to improve clarity of view
- ___ 8. Auxiliary view of webs or ribs
- ___ 9. Required to project true size of an oblique surface
- ___ 10. Inclined to all regular planes of projection
- ___ 11. First projection of an auxiliary view
- ___ 12. View from which auxiliary view is projected
- ___ 13. Auxiliary plane relationship to surface to be drawn
- ___ 14. Width is principal dimension in auxiliary view
- ___ 15. Classification of auxiliary view

- A. Primary auxiliary
- B. Hidden lines
- C. Secondary auxiliary
- D. Inclined line
- E. Auxiliary section
- F. Projectors
- G. Half auxiliary
- H. Oblique surface
- I. Circle
- J. Full auxiliary
- K. Partial auxiliary
- L. Cutting plane
- M. Center line
- N. Edge view
- O. Parallel
- P. Height auxiliary
- Q. Depth auxiliary
- R. Leaders
- S. Visible lines
- T. Width auxiliary

INFORMATION SHEET
ON
TECHNICAL SKETCHING

II-C-1(IS)

SUBJECT: Sketching Materials And Techniques

INTRODUCTORY
INFORMATION:

Sketching is the oldest form of recording one's thoughts. Evidence has been found showing that the pre-historic caveman used sketches to show the spot where an animal could most easily be wounded or killed.

Throughout the ages sketching has been used as a definite aid in recording shape descriptions. Records show that perhaps the greatest inventive genius in history, Leonardo da Vinci, filled sketch books with illustrations which fully described his ideas.

Today as in the past, sketching continues to be a form of conveying information or ideas from one person to another or as a means of developing an idea.

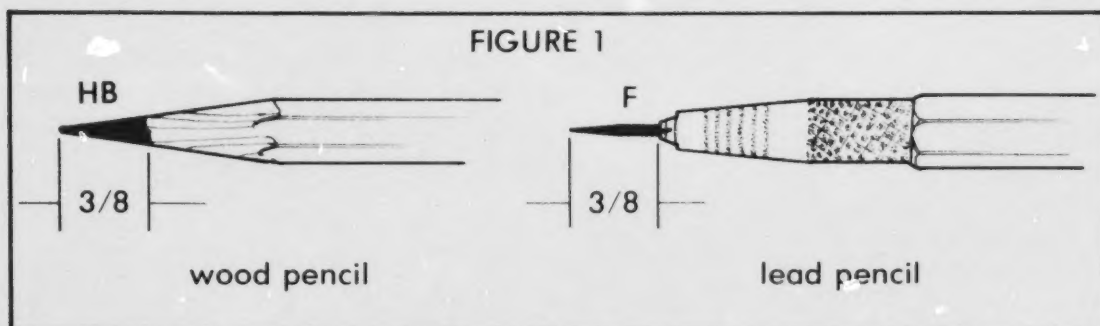
Sketching, as it is used in industry, is the right hand of technology. In the shop a sketch is used to assist someone in understanding a print; to explain a new idea such as a tooling requirement; or to explain an operation. The sketch may be made on an envelope, sketch pad, or a paper towel. It does not require artistic talent or mechanical tools to produce a technical sketch. All that is required is a basic understanding of the step-by-step principles and practices used in making a clear and comprehensive sketch.

GENERAL INFORMATION

Sketching Materials

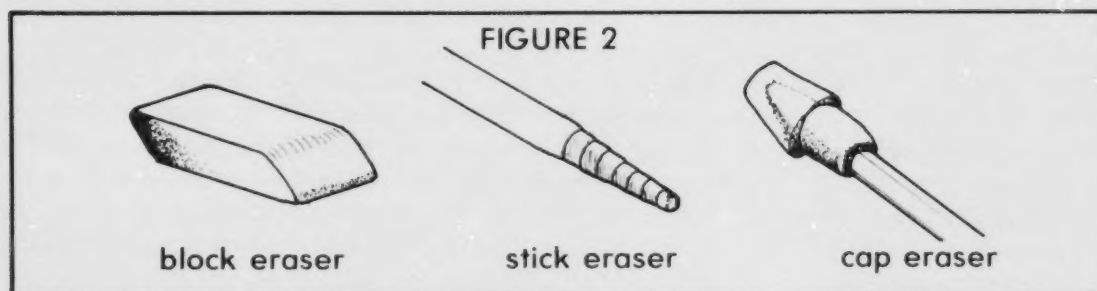
One of the advantages in technical sketching is that materials used for sketching are few and sketching can be done at any place or at any time. The only material requirements are a pencil, eraser, and paper, although some type of holder, such as a clip board or sketching pad, may be required to hold and support the paper.

The pencil used can be any type, although a medium soft pencil such as an F or HB drawing pencil or a common #2 writing pencil is preferred. A medium soft pencil is used because it can produce a soft gray line for the preliminary block-in of the sketch and also give a sharp or nearly sharp line, depending on the type of line required. With a hard lead it is difficult to produce a black line.

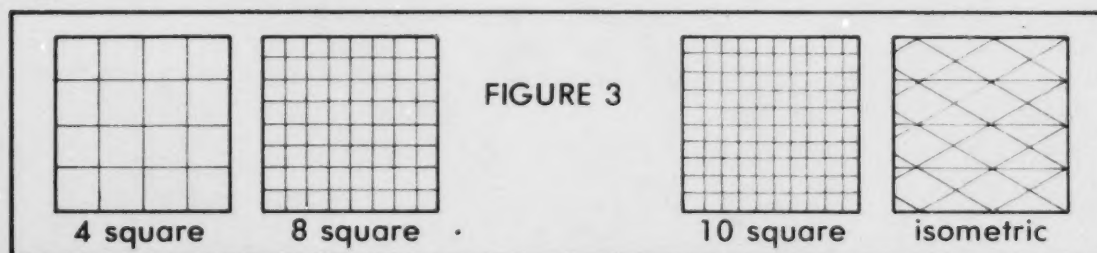


To produce quality lines requires the pencil to be sharpened correctly. A correctly sharpened pencil has a long (approximately $3/8$ ") conical point, as in Figure 1. Note: The point may be kept sharp by using a sanding pad or pencil sharpener.

Although the eraser on a pencil can be adequately used, a soft eraser such as the pink pearl or vinyl type is recommended. Both types are available either in block or stick form, as in Figure 2. Ink erasers are not recommended since the eraser contains coarse abrasive materials that will damage the paper.



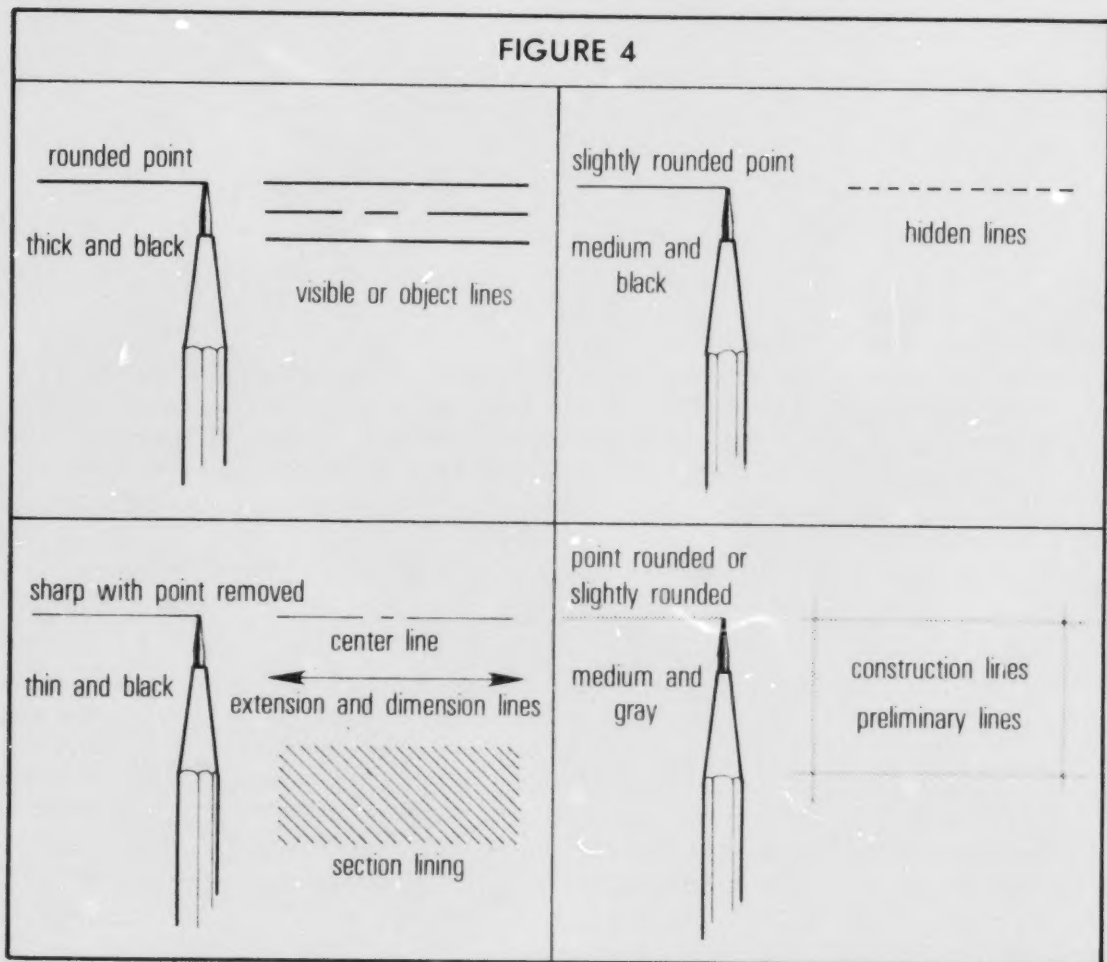
Coordinate paper is recommended for sketching, although any type of paper can be used. The ruled lines of the paper provides a guide for sketching lines straight and square and provides a means of sketching to scale. Cross-section paper or coordinate paper, as it is called, usually is divided into 4 spaces ($1/4$ " squares), 8 spaces ($1/8$ " squares), or 10 spaces ($1/10$ " squares), as illustrated in Figure 3, and is usually sold in pads similar to a tablet. It is either printed on heavy opaque or thin transparent paper. The lines are printed in a light color such as orange, blue, or green. Special types of ruled paper are also available for special drawings, such as isometric sketch paper, shown in Figure 3, that is used in making an isometric pictorial drawing.



Sketching Techniques

Even though there is no absolute rule for sketching techniques, there are a few recommendations that will help in making a good sketch. Among these are proper methods of holding the pencil; sketching different line thicknesses; erasing techniques; and sketching straight and curved lines.

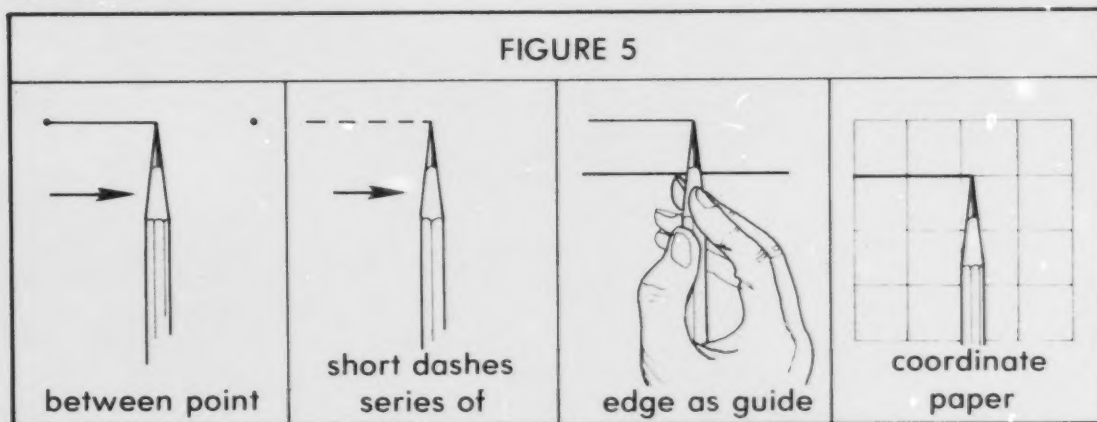
The pencil should be held in a natural position, usually at a 50° - 60° angle to the paper and about $1\frac{1}{2}$ to 2" from the point. As a line is drawn, the pencil should be rotated to keep the point from wearing flat. This may be done by turning the pencil approximately $1/6$ revolution after each sketched line. Pressure on the pencil should be constant, allowing the point of the pencil to determine proper line weight. See Figure 4.



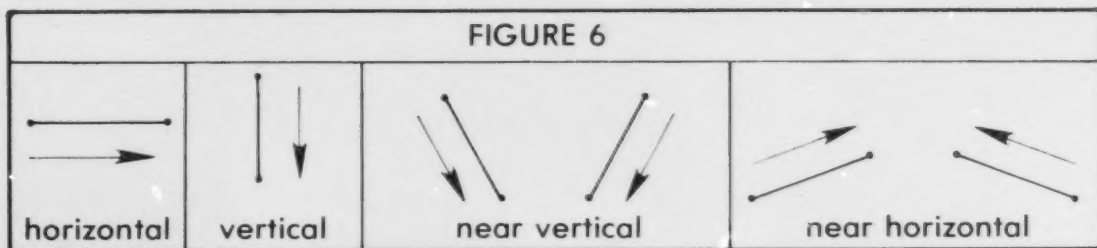
The appearance of any sketch can be ruined if erasing techniques are careless and sloppy. Erasers should be clean and free of oil and dirt from one's hands. Erasing pressure should be light so as to prevent smudging or tearing the paper. The eraser can be cleaned by rubbing on a scrap piece of paper prior to erasing.

Sketching of straight lines will vary with the individual and will not be perfectly straight, but every effort should be made to make the line reasonably straight with a certain degree of freedom for individual character desired.

There are three basic straight lines used in sketching. They are: horizontal, vertical, and inclined lines. Each line may be sketched neatly by using one of four techniques: (1) mark extreme ends of line with two points and move pencil from one point toward other; (2) by sketching a series of short lines; (3) using the edge of the paper as a guide; and (4) using the lines of coordinate paper as a guide. Study methods below in Figure 5.



The direction the pencil is moved will be determined by the type of line - vertical, horizontal, or inclined - and whether the person is left or right handed. For a right handed person horizontal lines are drawn from left to right. A left handed person would draw from right to left. Vertical lines are drawn from top to bottom or downward. The direction of inclined lines will be either downward for near vertical lines and upward for near horizontal lines. See Figure 6 for illustration of each.

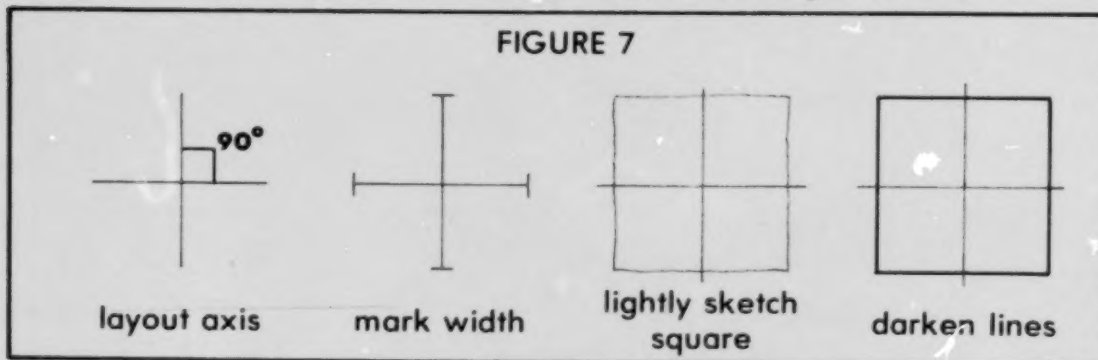


Regardless of the method used it is important to keep your eye on the point toward which you are drawing and to maintain a free and easy wrist-and-arm motion.

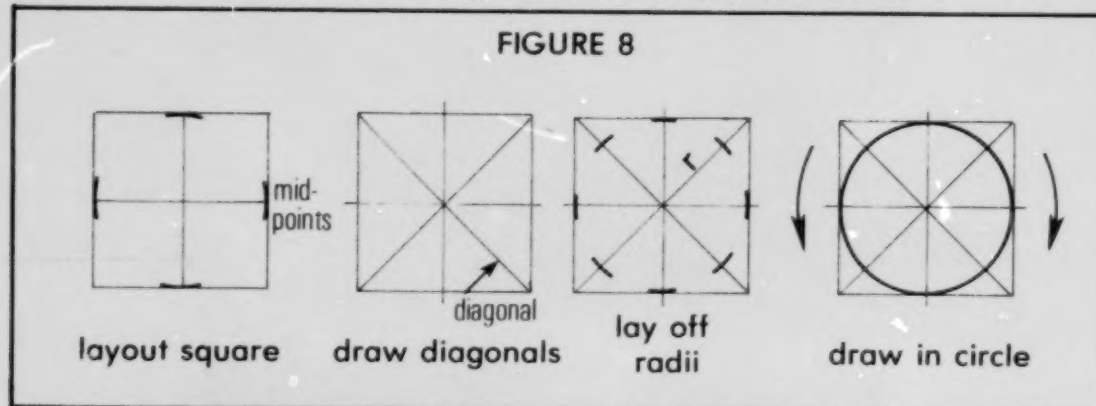
Sketching Geometric Shapes

Any object that may be viewed is made up of basic geometric shapes, such as squares, rectangles, triangles, and circles or curved lines. It is important that each shape be described accurately. This may be done by having a knowledge of the geometric shape and the technique that will assist in best describing the shape.

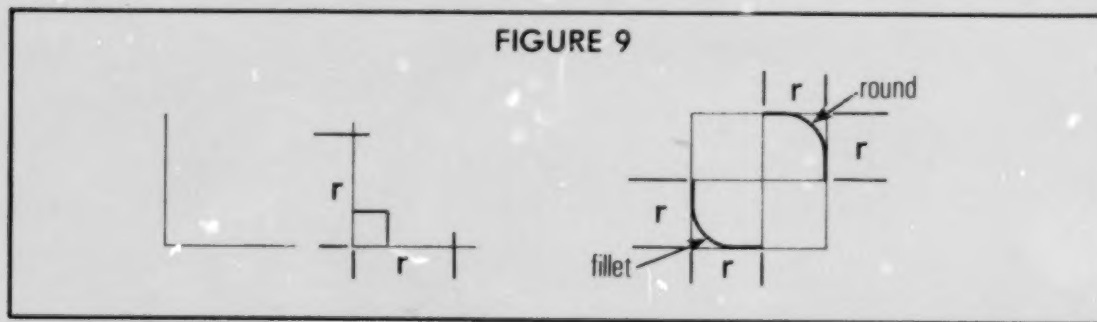
Squares and rectangles can best be sketched by laying out two axes at right angles to each other, and then with the use of the pencil as a gage lay out the height and width. Sketch horizontal and vertical lines through the point as in Figure 7.



Circles and arcs are easily sketched by first lightly drawing a square the size of the circle or arc. Figure 8 shows the procedure used to sketch a circle.

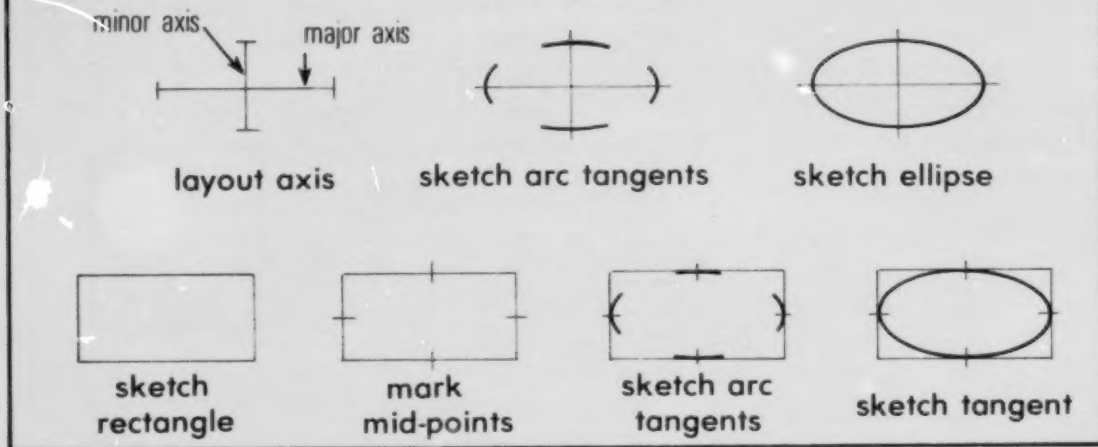


Arcs are sketched in the same way except only one quadrant of the circle is used, as shown in Figure 9.



A circle viewed at an angle appears as an ellipse. Instead of all points on the curve being equidistant from the center, there are two axes. One axis appears shorter than the other. The long axis is called the major axis and the short axis is the minor axis. Figure 10 illustrates two methods of sketching an ellipse.

FIGURE 10

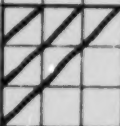
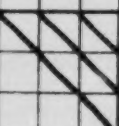
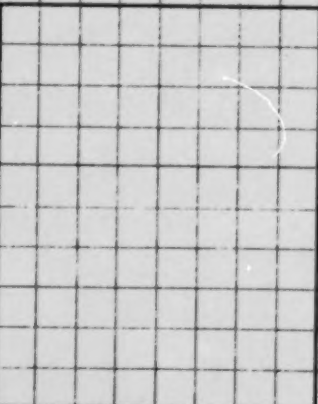
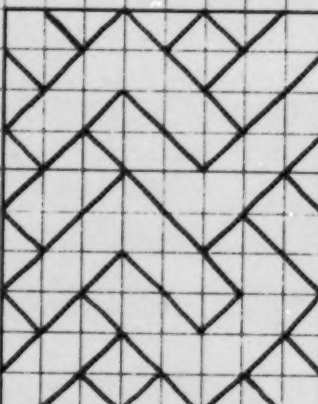


ASSIGNMENT SHEET
IN
SKETCHING

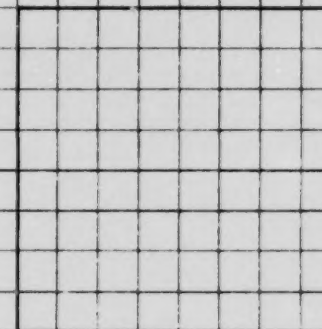
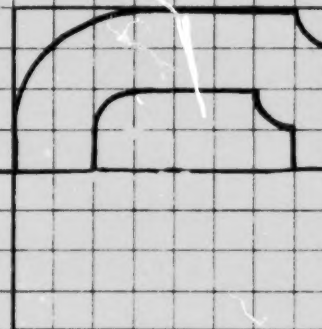
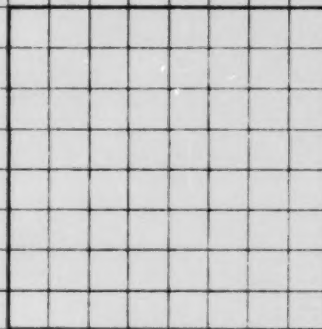
II-C-1(AS)

- SUBJECT:** Sketching Straight and Curved Lines
- AIM:** The student will exhibit skill in the technique of sketching straight and curved lines and the selection of materials used in sketching.
- INTRODUCTORY INFORMATION:** Sketching is a quick and simple method of formulating, expressing, and recording new ideas or clarifying a point. Although sketching requires no absolute technique, there are certain guidelines one should follow in order to produce a neat and clear drawing. These techniques include methods of sketching lines, arcs, and geometric figures and maintaining proper proportion when sketching. This Assignment Sheet will enhance the student's ability to sketch clear, distinct, and uniform lines and geometric figures that are essential in orthographic or pictorial sketching.
- REFERENCE:** Information Sheet II-C-1(IS) "Sketching Materials and Techniques"
- QUESTIONS OR PROBLEMS:**
1. Assignment Sheet II-C-1(AS) Number 1 develops the skill of the student in sketching straight lines, including horizontal, vertical, and inclined. Each problem has an illustration of the skill the student is to develop by duplicating the illustrated skill. The student is expected to complete the problems, working to maintain clean, sharp, distinct lines as discussed in Information Sheet II-C-1(IS) "Sketching Materials and Techniques".
 2. In Assignment Sheet II-C-1(AS) Number 2, the student will develop skill in sketching curved lines such as arcs and circles. Each problem has a partial illustration of the skill the student is to perform by completing the illustration and duplicating it. All curved lines should be sketched with sharp, distinct, and smooth curved lines. All construction lines used to lay out the circle should be drawn lightly so as to give contrast to the drawing. Information Sheet II-C-1(IS) "Sketching Materials and Techniques" is to be used as a guide in developing these skills.

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NAME:	ORTHOGRAPHIC SKETCHING		DATE:
1			

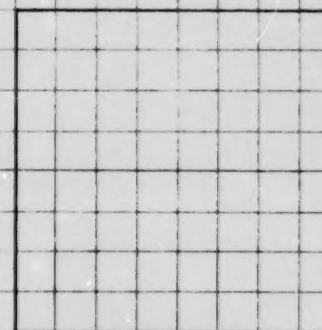
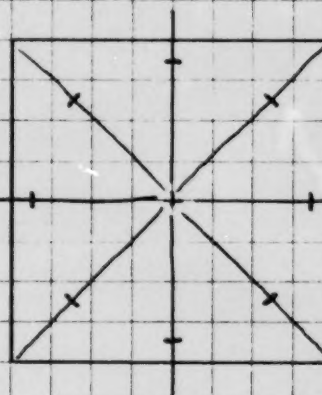
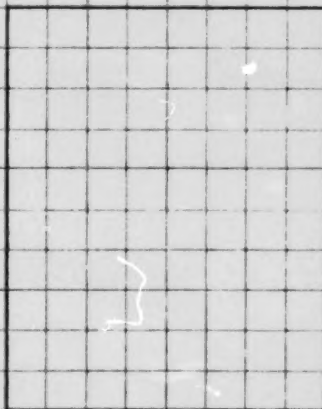
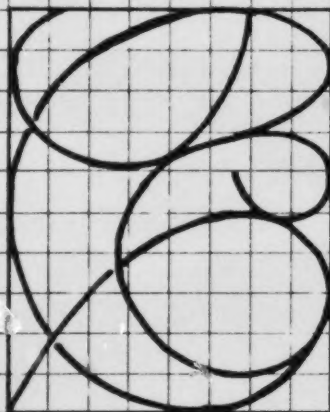
131



1. COMPLETE CIRCLES AND DUPLICATE IN SPACE TO RIGHT.

2. SKETCH LOWER HALF SYMMETRIC.

DUPLICATE DESIGN AT LEFT.



3. DUPLICATE DESIGN SHOWN AT LEFT.

4. SKETCH CIRCLE THROUGH POINTS MARKED.

DUPLICATE CIRCLE AT LEFT.

NAME:

ORTHOGRAPHIC SKETCHING

DATE:

2

113

114

INFORMATION SHEET
ON
TECHNICAL SKETCHING

II-C-1a(IS)

SUBJECT: Proportion And Making An Orthographic Sketch

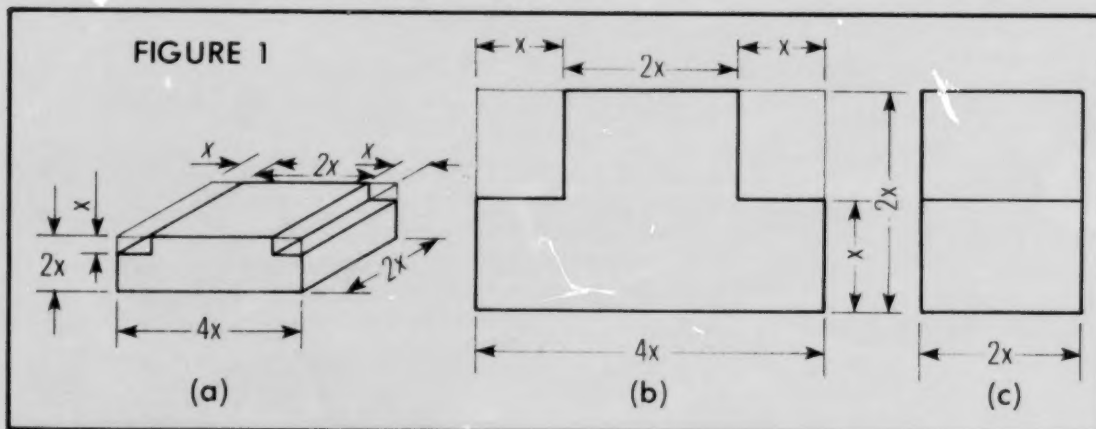
INTRODUCTORY
INFORMATION:

There is an old saying, "be the labor great or small, do it well or not at all." This saying applies especially to sketching. Proportions "make or break" a sketch, whether a single view, multi-view, or a pictorial sketch. Proportion is the size relationship of the component of an object to each other and with the whole size of the object. It also can be defined as making the component parts of an object harmonious or symmetrical through their size relationship. Regardless of how well the view selection and line techniques, if the proportions of an object are bad, the sketch will appear bad. This is especially true of the large overall proportions.

Estimating Proportion

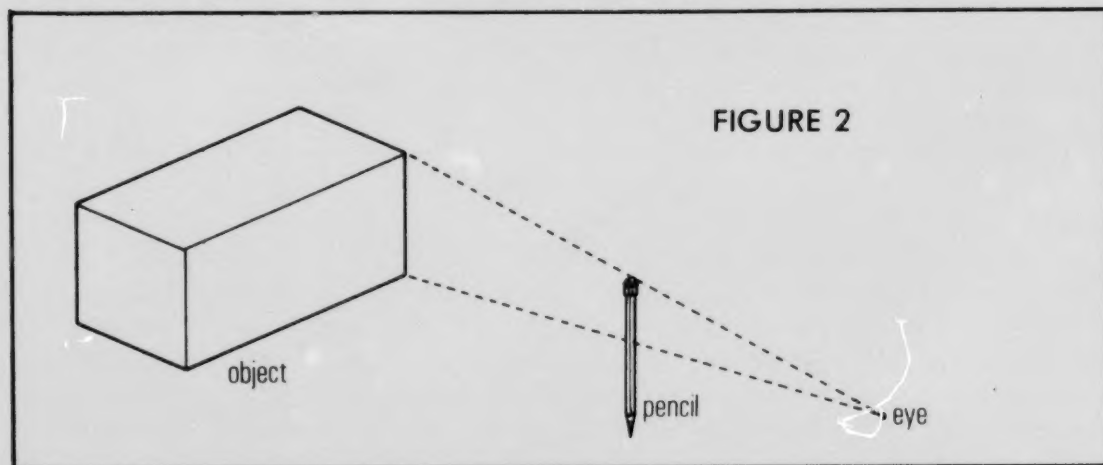
Proportion may be determined by three different methods. They are (1) approximation by eye; (2) approximation by pencil and eye; and (3) actual measurement. The method used will be greatly determined by what is to be sketched and the availability and size of the object. An object that can be measured will provide more accurate information, while large objects will require estimation by eye, or by eye and pencil. New ideas will require personal knowledge of good proportion.

The method of obtaining proportion through approximation by eye is the most practical and quickest method since no measurements are made. The object to be sketched is carefully studied and the sizes and shapes of component parts are noted. The size of the various shapes are compared with each other and with the overall height, depth, and width of the object. This relationship is obtained by comparing general areas and distances visually, as in Figure 1(a).

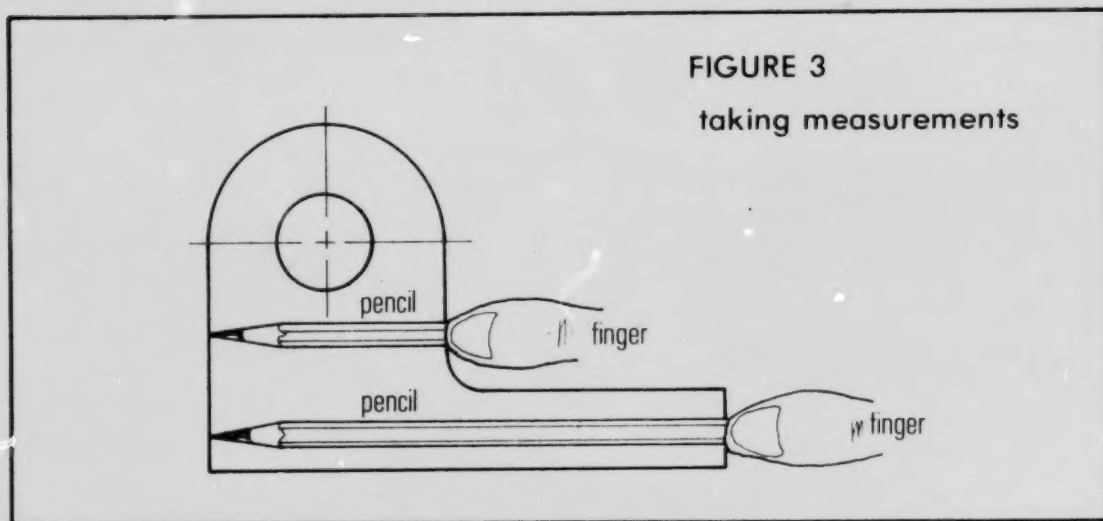


The overall height and width of the front view is blocked in lightly. The basic shape and component parts are then blocked in, as in Figure 1(b). The depth and height is compared and the end view is blocked in, as in Fig. 9(c). All object lines are then darkened in.

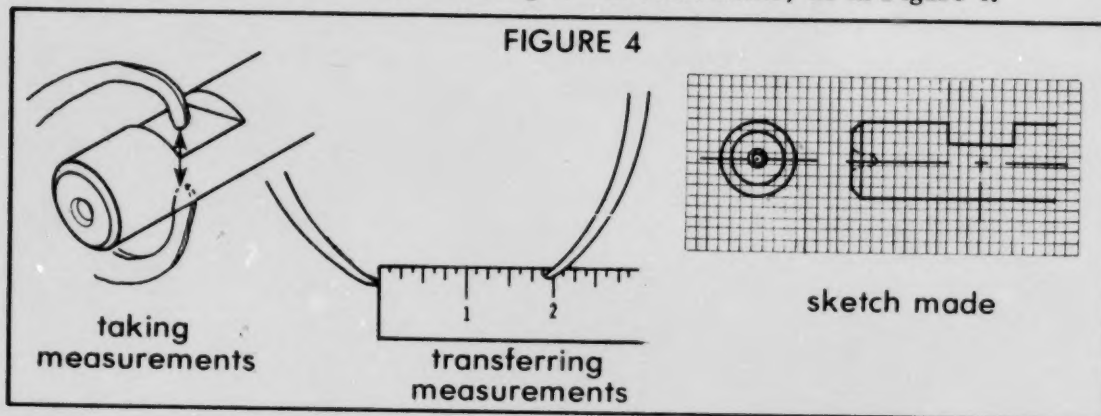
The use of the pencil and eye method of obtaining proportion is frequently used by artists and engineers. In this method a pencil is held at arm's length and sighted along the object, as in Figure 2, and noting the length on the pencil. The lengths are transferred to the sketching paper as measured or by using the same proportion. It is very important to position the pencil the same distance from the eye each time in order to maintain proper proportion, as the dimension will increase or decrease if the hand is moved closer or farther from the eye.



For small parts, such as a machine part, the distance can be compared in the same manner by actually placing the pencil against the object itself, as in Figure 3. This method is frequently used in the shop.



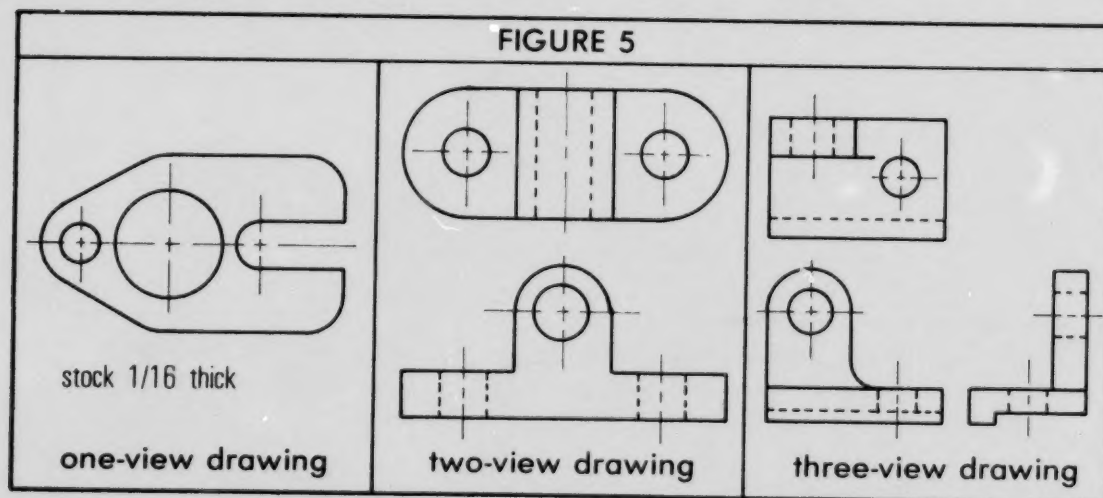
The most accurate and widely used method in the shop is to take actual measurements of the part and transfer them to coordinate paper. The sketch is drawn full size or to a scaled size, as in Figure 4. Measuring tools such as calipers, micrometers, or just a ruler are used in taking the measurements, as in Figure 4.



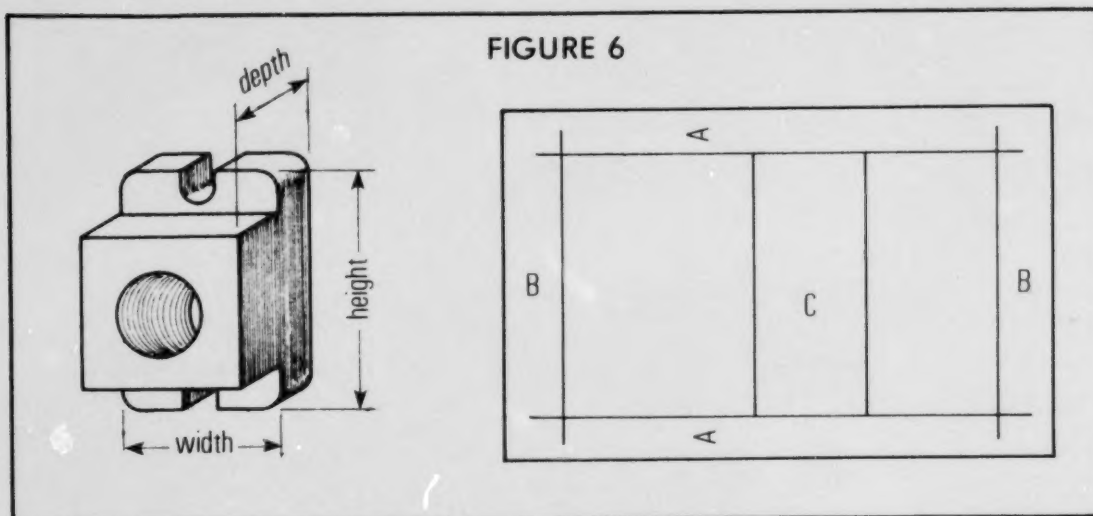
Orthographic Sketching

As true with any type of drawing, the orthographic sketch must give that information necessary to convey the idea, thought, or plan. The sketch may consist of a single view or multi-view drawing with or without dimensions applied. Regardless of the information to be given, there are steps or procedures that may be followed to produce a clear comprehensive sketch. The following procedure is recommended:

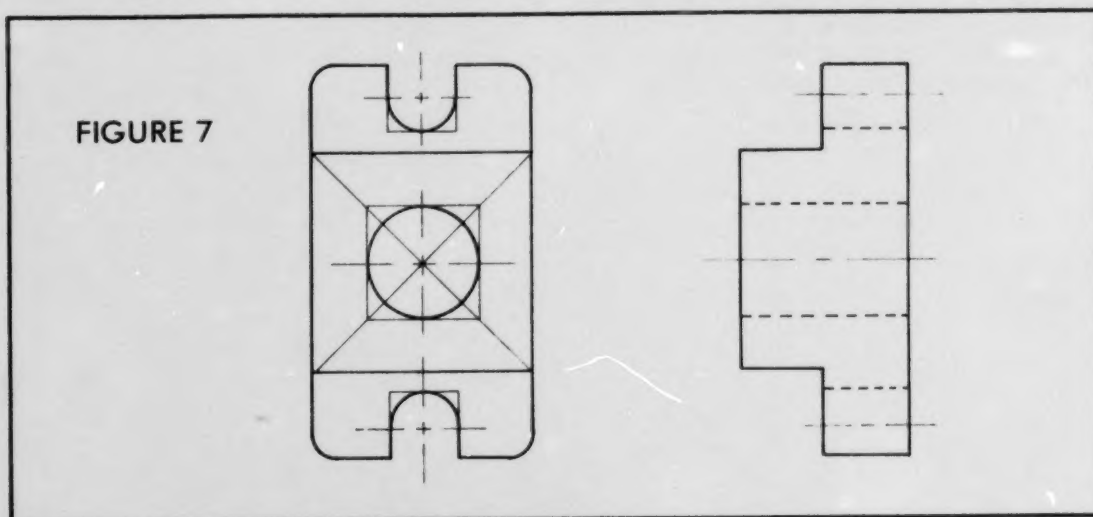
1. Select the views required. This may be one, two, or more views depending on complexity of part and information to be given. Select only the views needed for clear and complete shape description. Views that show best the essential contours or shapes with the minimum number of hidden lines are preferred, as in Figure 5. The front view should be selected first as it is the most important view and usually shows the shape of the object most clearly.



2. Block in views. The overall depth, height, and width are blocked in lightly with horizontal and vertical lines to establish the correct size proportion. Space is left between each view and the edge of the paper to provide a margin and room for dimensions and note, as shown in Figure 6 by spaces A, B, and C.

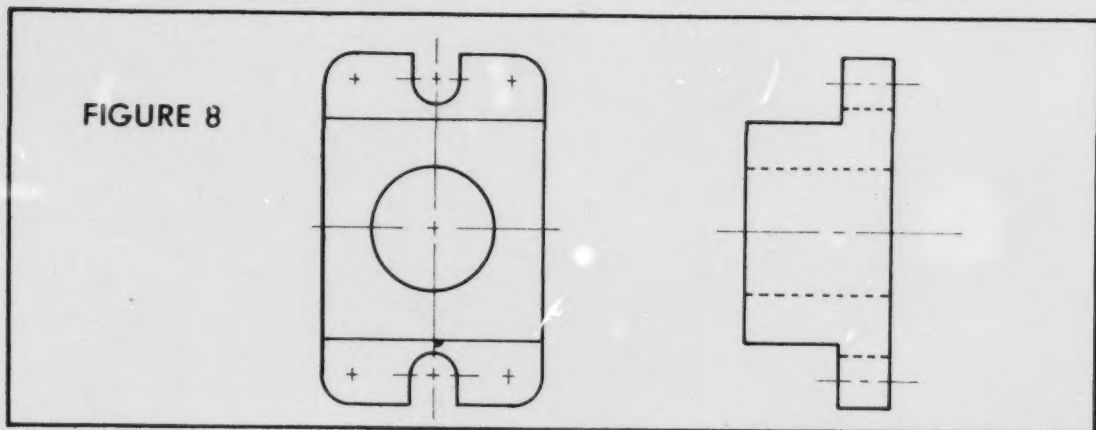


3. Locate center and arcs and block in smaller details. The center lines for all circles are located and blocked in, as are minor areas. Diagonals are drawn to locate the centers of the arcs and circles as illustrated in Figure 7.

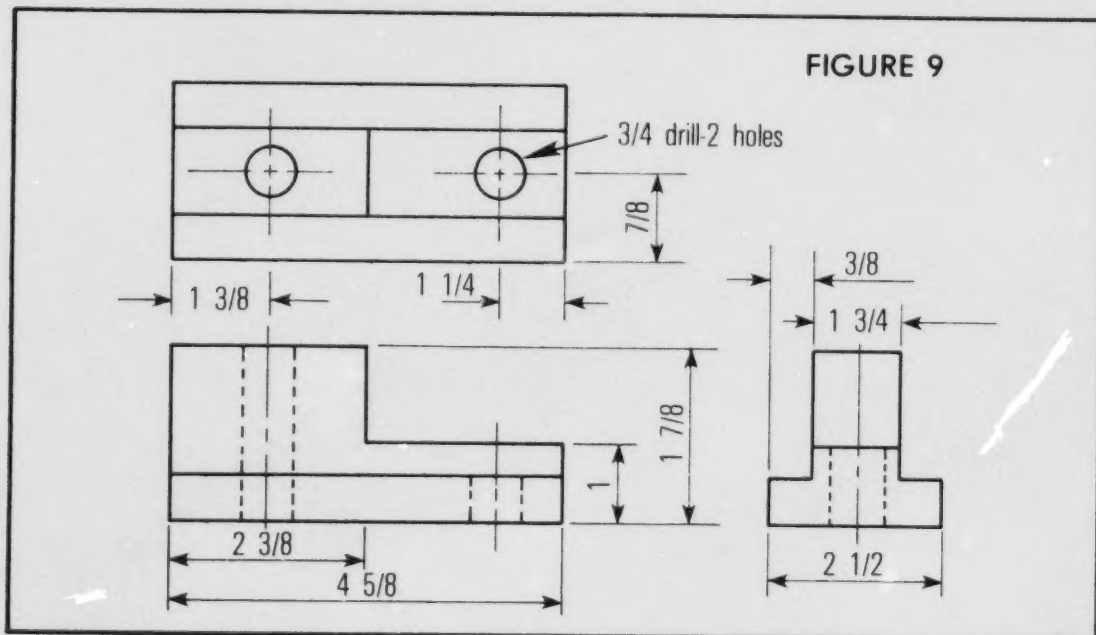


4. Darken in all visible lines - straight and curved. All visible edges are darkened with a sharp and snappy dark line. Straight lines should blend into curved lines at the tangent point. See Figure 8.
5. Darken in centers and center lines with sharp thin lines. Centers for small arcs are located with a small t. See Figure 8.

6. Darken in all hidden lines with medium lines, as seen in Figure 8.



7. Draw in extension lines, dimension lines, leader lines, and dimension part. At this point of a sketch all information relating to shape description has been given. In some cases, this will be all that is needed. If the sketch is to be used as a working drawing the application of dimensions will be required. The principles of dimensioning are complicated and have many rules and procedures. Although it would be well to know all of these practices, it is not practical to try and learn them as the person in the drafting department would, in such short time. One can learn through the experience of reading prints and the common knowledge of machine shop practices. Figure 10 illustrates some basic dimensioning techniques. It is important to remember that the sizes of all geometric shapes and their location with respect to each other be given as you have studied in previous lesson.



ASSIGNMENT SHEET
IN
SKETCHING

II-C-1a(AS)

SUBJECT: Orthographic Sketching

AIM: The student will exhibit skill in making an orthographic sketch.

INTRODUCTORY INFORMATION: An orthographic sketch does not require the exactness that is essential in a mechanical drawing, but there are certain techniques that are essential. In an orthographic sketch all lines must be shown and made correctly. The lines should be sharp and distinct, giving a contrast between the different types of lines, such as hidden lines and visible lines. Center lines are necessary to locate centers of arcs and circles, and construction lines should be used for the initial layout. Where dimensions are to be used, dimensioning techniques studied in Information Sheets II-B-3(IS) and II-B-3a(IS) are to be followed. The student should constantly observe good line work as practiced in Assignment Sheet II-C-1(AS) "Sketching Straight and Curved Lines". The constant practice of good proportion should be observed, since poor proportion will make the overall sketch poor. This assignment will enhance the student's ability to make a clear, distinct, and well proportioned sketch.

REFERENCES: Information Sheet II-C-1(IS) "Sketching Materials and Techniques"
Information Sheet II-C-1a(IS) "Proportion and Making An Orthographic Sketch"

**QUESTIONS
OR
PROBLEMS:**

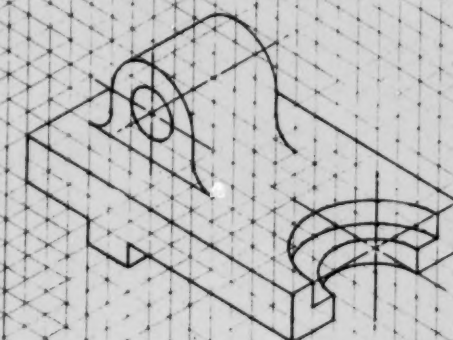
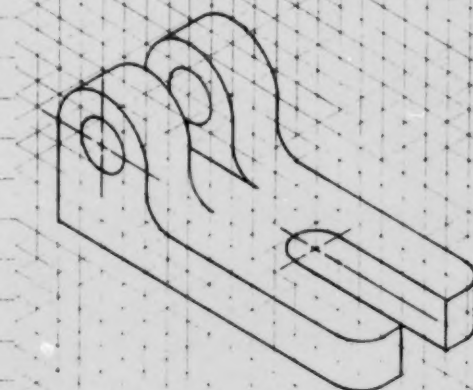
1. Assignment Sheet II-C-1a(AS) will provide the student with problems in making an orthographic sketch. Problems 1 and 2 have a pictorial view of the object to be sketched with two orthographic views given. The student will study the pictorial drawing and the two given views and complete the missing view. Care should be taken to show all lines and sketch each line neatly and correctly. The coordinate grid and isometric grid are to be used to provide size proportion.
2. Problems 3 and 4 provide the student with a greater challenge in that only the pictorial sketch and the location of key centers are provided. The student will study the pictorial view and sketch the top, front, and right side views. The coordinate and isometric grid will provide the student with a reference for size proportion.
3. Problem 5 will enhance the student's ability to develop a sense of proportion in sketching. The student will study the given pictorial view and sketch the top, front, and right side views. The sketch is to be made using the student's own perception

II-C-1a(AS)

of proportion, rather than a formal measuring tool, such as a rule or divider. The student is to strive for good proportion in addition to good line work and correctness of the drawing.

NAME:	ORTHOGRAPHIC SKETCHING	DATE:	1

NAME:	ORTHOGRAPHIC SKETCHING
DATE:	2

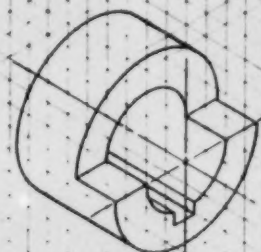
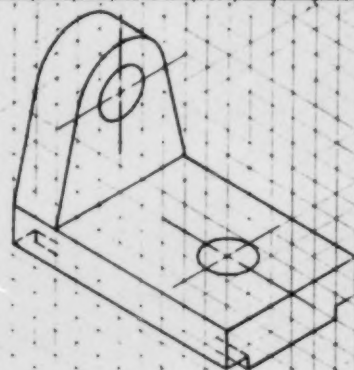


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ORTHOGRAPHIC SKETCHING

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3



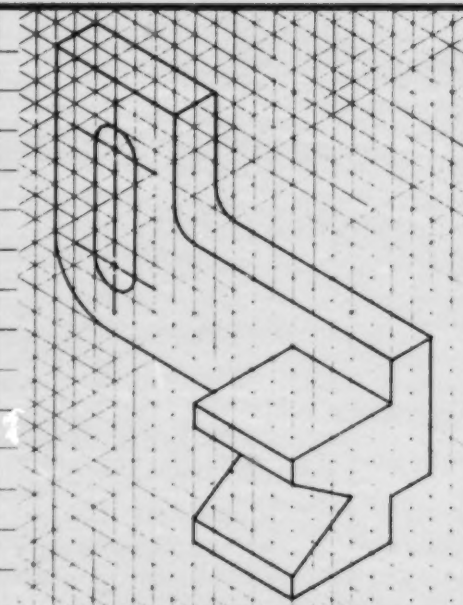
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ORTHOGRAPHIC SKETCHING

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4

149



NAME:

ORTHOGRAPHIC SKETCHING

DATE:

5

126

127

TRUE - FALSE TEST
ON
ORTHOGRAPHIC SKETCHING

II-C-1(T)
p. 1 of 3

NAME _____

DATE _____

DIRECTIONS: Read each of the following statements carefully. Some of the statements are true and some are false. Indicate the correct answer by placing a small circle around the T or F in the corresponding right hand column.

- EXAMPLE:** 1. Leonardo da Vinci was an inventive genius. ☒ T F
1. Sketching is a form of technical drawing that requires the use of mechanical drawing instruments. T F
2. Sketches can be either pictorial or orthographic drawings. T F
3. An advantage of technical sketching is that the required material is inexpensive. T F
4. Four grid coordinate paper has 16 squares per square inch. T F
5. Ink erasers will give a clean erasure without damage to the paper. T F
6. Light will penetrate opaque paper. T F
7. Lines on coordinate paper inclined to each other. T F
8. Sketching allows for a certain amount of individuality in the line work. T F
9. The construction of a sketched circle is developed from a square. T F
10. Proportion of a drawing is the size relationship of the component parts to each other. T F
11. The proportion of a drawing is of little importance to a drawing. T F
12. The number of views to be drawn is determined by the complexity of the drawing. T F
13. Coordinate paper provides an accurate method of sketching a drawing to scale. T F
14. A circle viewed at an angle will appear as an ellipse. T F
15. A 3H pencil is recommended for sketching. T F

- | | | |
|---|---|---|
| 16. Rotating a pencil while sketching will prevent the pencil point from wearing flat. | T | F |
| 17. Visible or object lines are drawn thin and black. | T | F |
| 18. Construction lines are used to block in a drawing. | T | F |
| 19. Vertical lines are drawn by pulling the pencil upward from bottom to top. | T | F |
| 20. The direction an inclined line is drawn is determined by the angle of the line. | T | F |
| 21. The largest diameter of an ellipse is called the major axis. | T | F |
| 22. Rotation of the pencil will help maintain sharp and uniform weight of lines. | T | F |
| 23. The normal direction for sketching a horizontal line for a right handed person is from right to left. | T | F |
| 24. To clean a dirty eraser one should wash the eraser. | T | F |
| 25. Rulers are a common tool used for taking measurements of a part. | T | F |

MATCHING TEST

II-C-1(T)
p. 3 of 3

DIRECTIONS: One item from Column I is closely related to or associated with an item in Column II. Place the capital letter of the associated term in Column II in the blank space at the left of the number in Column I.

EXAMPLE: C 1. Angle pencil is held

- A. Perpendicular
- B. Horizontal
- C. 50 - 60 Degrees

Column I

Column II

- | | |
|---|-------------------|
| <u> </u> 1. Permits light to pass through | A. Ink eraser |
| <u> </u> 2. Freehand drawing | B. Tangent |
| <u> </u> 3. Size relationship | C. Coordinate |
| <u> </u> 4. Circle viewed at an angle | D. HB |
| <u> </u> 5. Shape of pencil point | E. Major axis |
| <u> </u> 6. Coarse abrasive material | F. Ellipse |
| <u> </u> 7. Sketching paper with squares | G. By eye |
| <u> </u> 8. Short axis of an ellipse | H. Rotate pencil |
| <u> </u> 9. Quick method to determine proportion | I. Transparent |
| <u> </u> 10. Largest diameter of an ellipse | J. Arc |
| <u> </u> 11. Point where curved and straight line blend together | K. Opaque |
| <u> </u> 12. Medium soft lead | L. Conical |
| <u> </u> 13. Required to maintain conical point | M. Sketch |
| <u> </u> 14. Geometric figure with four equal sides | N. Hole |
| <u> </u> 15. Portion of a circle | O. Minor axis |
| | P. Eye and pencil |
| | Q. 4H |
| | R. Proportion |
| | S. Square |
| | T. Rectangle |

INFORMATION SHEET
ON
TECHNICAL SKETCHING

II-C-2(IS)

SUBJECT: Pictorial Sketches

**INTRODUCTORY
INFORMATION:**

A pictorial drawing is one in which the object is viewed in such a position that three faces appear in a single view. Pictorial drawings are excellent for showing an object in three dimensions and are frequently used to supplement work drawings or to assist untrained people in understanding views they cannot visualize in a regular print.

Pictorial drawings are used extensively in sales literature; assembly drawing; and in technical illustrations. One of the most common uses of pictorial drawings in the machinist field is the pictorial sketch which is a simple and quick method explaining or illustrating an idea.

It is to the advantage of a machinist to develop skills in making a pictorial sketch quickly and accurately. To develop these skills requires an understanding of the various types of pictorial drawings and techniques used in making a pictorial sketch.

GENERAL INFORMATION

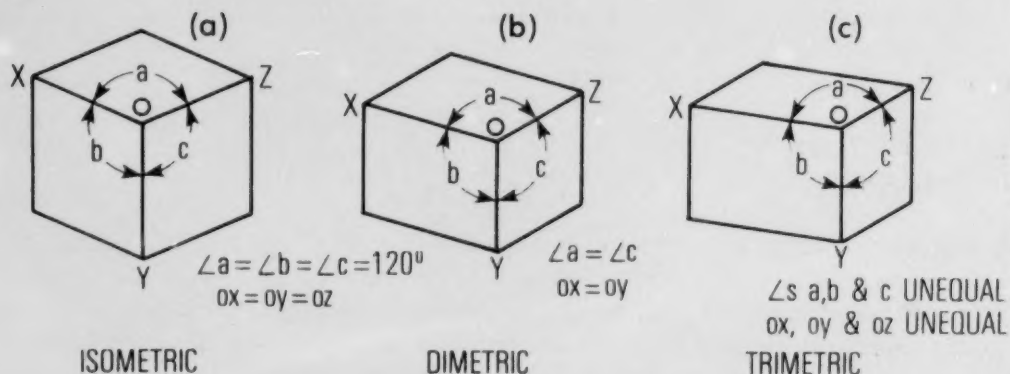
Types of Pictorial Drawing

Pictorial drawings are classified by the position the front face makes with the plane of projection and the angle and depth the receding lines project.

Pictorial drawings can be divided into three main types: (1) axonometric; (2) oblique; and (3) perspective. Each of these have different divisions which have their own characteristics. Although there are many applications for perspective drawings, they are not used frequently in the machinist trade.

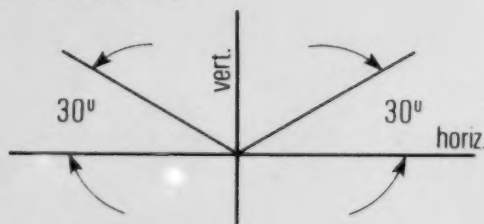
Axonometric drawings have the principal edges and surfaces inclined to the plane of projection causing the lengths of the lines, the sizes of the angles, and the general proportions of the object to vary. There are three classes of axonometric projections: (1) isometric, (2) dimetric, and (3) trimetric. Figure 1 shows the comparative differences among the three. We will concern ourselves with the isometric view since it is the most common axonometric projection used.

FIGURE 1 AXONOMETRIC PROJECTION



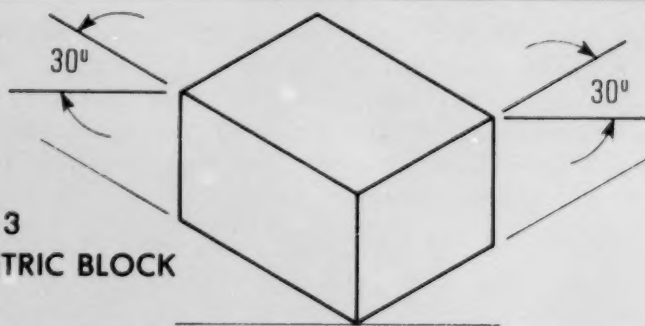
Isometric drawings are positioned so that the principal edges or axes make equal angles with the plane of projection and therefore are foreshortened equally. See Figure 1. The principal edges form an axis referred to as the "Isometric Axis". The term isometric means "equal measure". The isometric axes are uniformly spaced at 120 degrees. The edges that project width and depth are drawn 30 degrees to the horizontal and the front edge, projecting height, will be vertical. See Figure 2.

FIGURE 2 ISOMETRIC AXIS

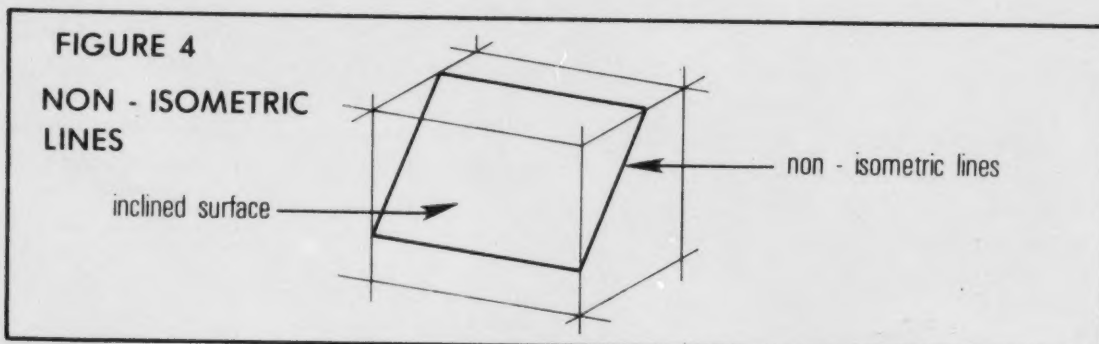


All lines parallel to the isometric axis are called "isometric lines" and are laid out along the isometric axis forming an isometric block as in Figure 3.

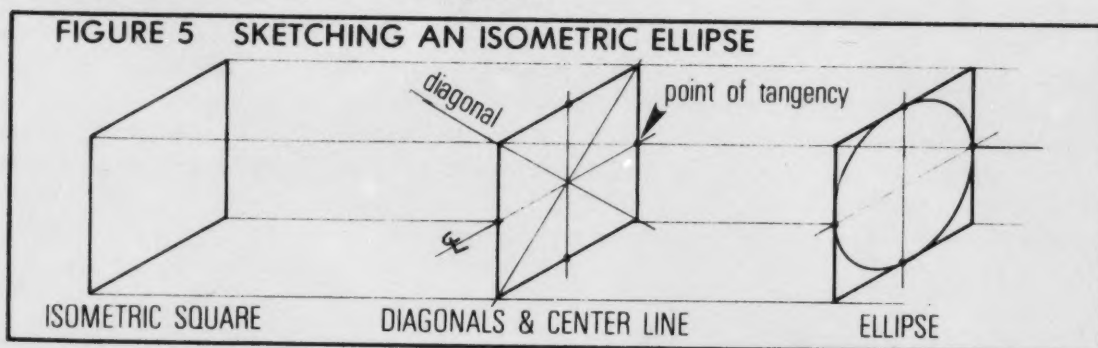
FIGURE 3
ISOMETRIC BLOCK



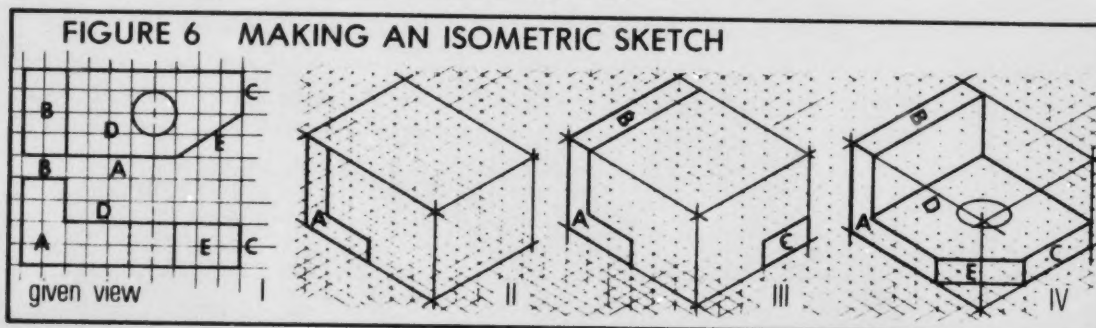
Edges that are not parallel to the isometric axis will not project true length and cannot be measured directly on the isometric axis. These lines are called "non-isometric lines". Non-isometric lines must have the end points located on the isometric lines first. The two points are then connected, forming a non-isometric line as shown in Figure 4.



Circles in isometric will appear as ellipses. Arcs will appear as a part of an ellipse. The isometric circle is sketched somewhat the same as an orthographic circle, as an isometric square is sketched first with the diagonals of the square and center lines then drawn. This forms the boundaries and tangency points on the ellipse. The ellipse is then sketched in. See Figure 5.



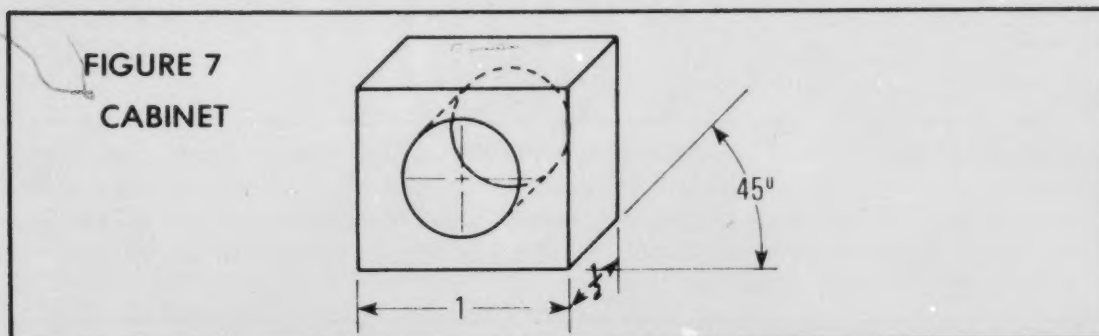
One of the best aids in learning to sketch in isometric is the use of isometric paper. The lines of the paper form the axis of the isometric projection and permits the isometric grids to be used for sketching to size. Figure 6 illustrates the use of isometric paper and the steps in making an isometric sketch.



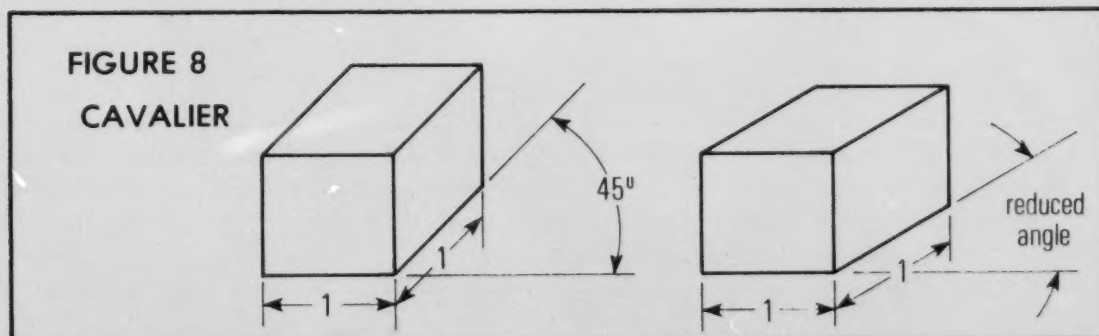
Oblique drawings are perhaps the easiest type of pictorial drawings to make. In the oblique drawing, one face of the object is parallel to the plane of projection and is viewed in true size and shape. The oblique drawing uses three axes as does the isometric drawing with this exception; two of the oblique axes are at right angle to each other and the third axis (receding axis) is projected at any convenient angle to the horizontal. All receding edges are drawn parallel.

There are three classifications of oblique projections: cabinet, cavalier, and general.

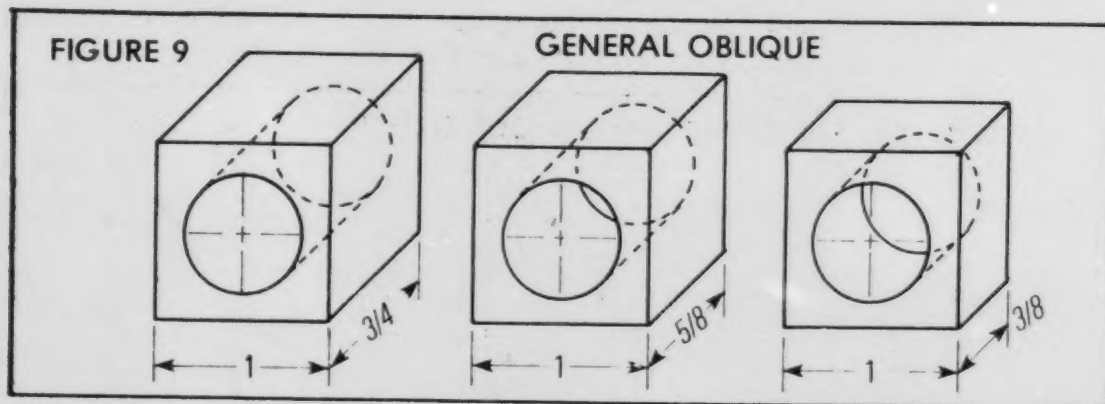
The cabinet oblique drawing normally has the receding lines drawn at a 45-degree angle. The scale or size of the receding lines is reduced to one-half, which gives a more natural appearance. See Figure 7.



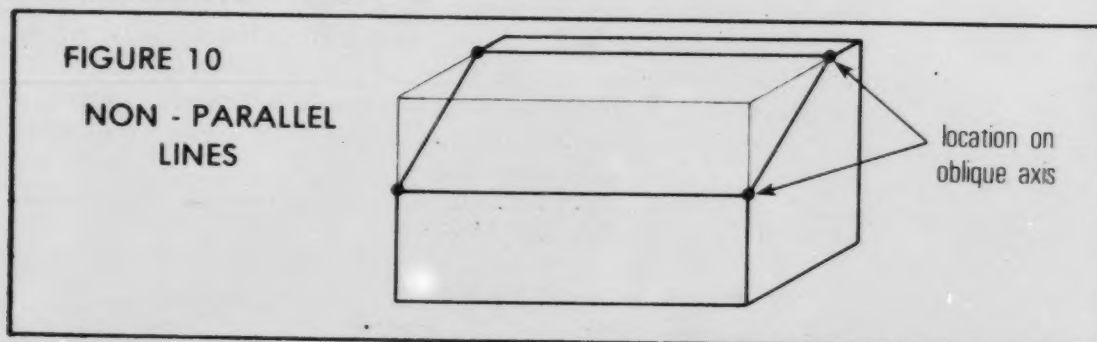
The cavalier oblique drawing is one in which the receding axis can be any angle but usually 30 or 45 degrees. The scale or size is the same on all axes, that is to say that all axes are drawn full size. This causes the object to appear distorted. However, distortion can be eliminated to some degree by reducing the angle of the receding axes. See Figure 8.



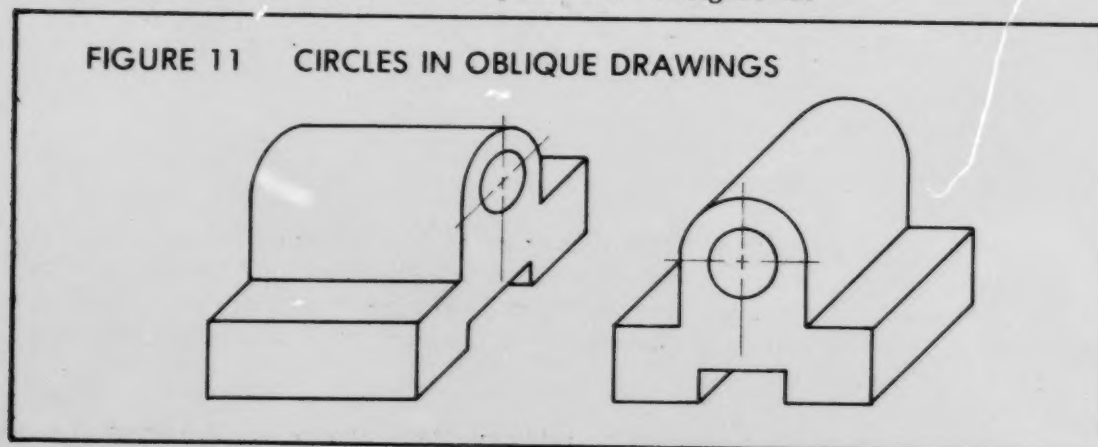
The general oblique drawing is one in which the receding axis is usually between 30 and 60 degrees. The scale of the receding axis is variable and may vary from full size to three-eighths size, in order to obtain the most natural appearance of the object. See Figure 9.



Edges that are oblique or inclined must be laid out on the oblique axis in the same manner as they would be in an isometric drawing. The end points are located and the lines drawn, as in Figure 10.



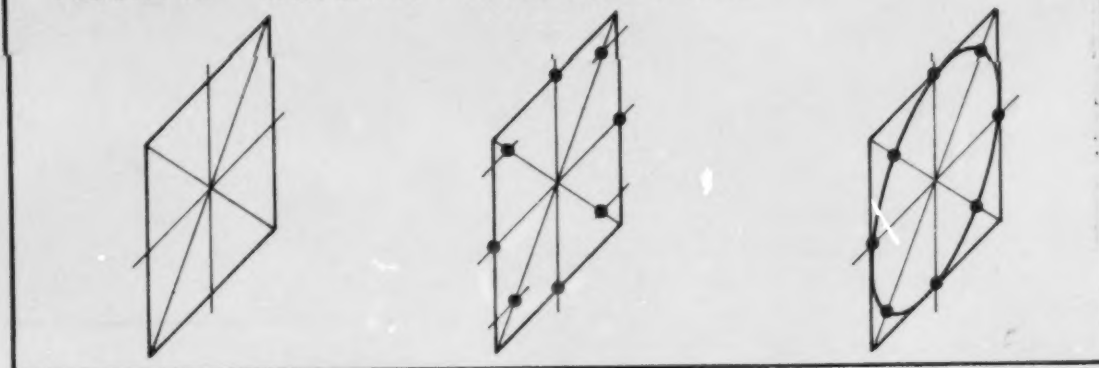
The chief advantage of oblique drawing is the ease with which circular shapes can be drawn. In positioning the object, circular shapes will appear in true shape and size if viewed in the front face. Circular shapes that are not faced toward the front are viewed elliptical and distorted. Compare views in Figure 11.



When it is necessary to show a circular shape in a receding face, the same procedure as for drawing an isometric circle is used. An oblique square is sketched first. The

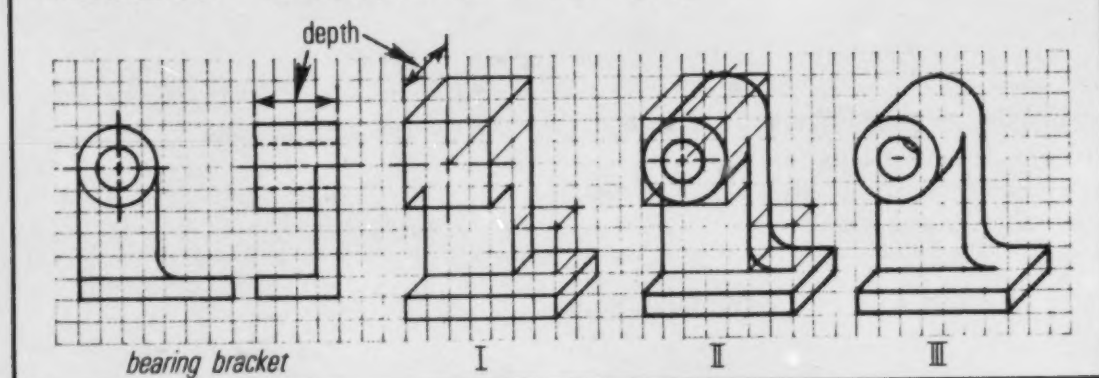
diagonals and center lines are drawn. The oblique square provides the boundaries for the circle and the center lines locate the points of tangency. See Figure 12.

FIGURE 12 SKETCHING AN OBLIQUE ELLIPSE



Oblique sketches can be made satisfactorily on ordinary coordinate (cross-section) paper. The lines drawn perpendicular to each other provide a guide for two of the oblique axes. Forty-five degree lines can be sketched easily by drawing diagonals through the squares. Dimensions are counted off on the grid of the paper. Figure 13 illustrates the procedure for making an oblique sketch.

FIGURE 13 MAKING AN OBLIQUE SKETCH

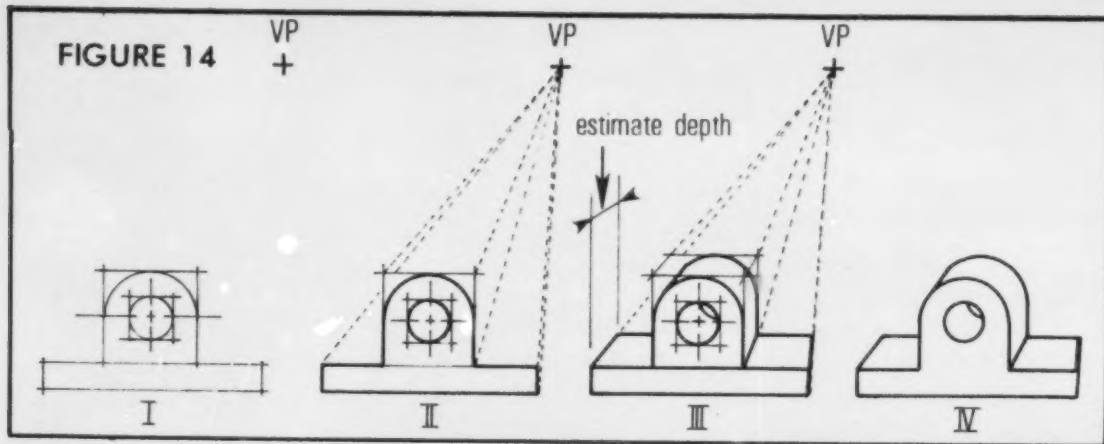


From a given orthographic sketch.

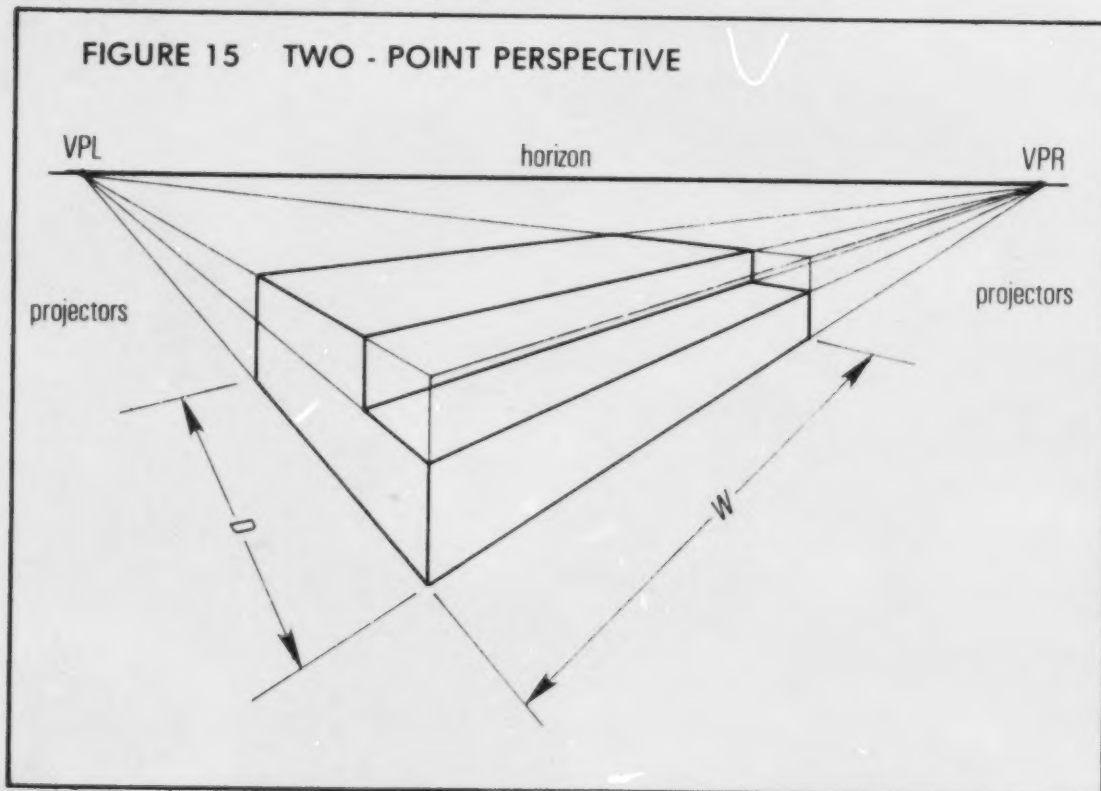
Perspective Drawings - The eye and camera are both constructed so that objects appear progressively smaller as they are viewed farther away. An example of this would be looking at the spacing between the rails of a railroad track or the height of fence posts. They all appear to disappear with distance. The point of disappearance is called the vanishing point.

Perspective drawings are developed on this principle. There are two types of perspective drawings: (1) parallel and (2) angular. In the parallel perspective (one-point) the front face is drawn as in the oblique drawing. Receding lines are projected

to a position where they become a point. This point is called the vanishing point (VP). See Figure 14.



In angular perspectives (two-point), which is the most true to life of all pictorial methods, two vanishing points are used. The vanishing points are located on the horizon (eye level). They are located to the left and right of the object. The corner edge of the object is drawn true size and the receding lines project to the vanishing points, labeled VPL (vanishing point left) and VPR (vanishing point right). The depth and width are laid out along the projectors.



ASSIGNMENT SHEET
ON
SKETCHING

II-C-2(AS)

SUBJECT: Pictorial Sketching

AIM: The student will be able to make an pictorial sketch correctly and accurately.

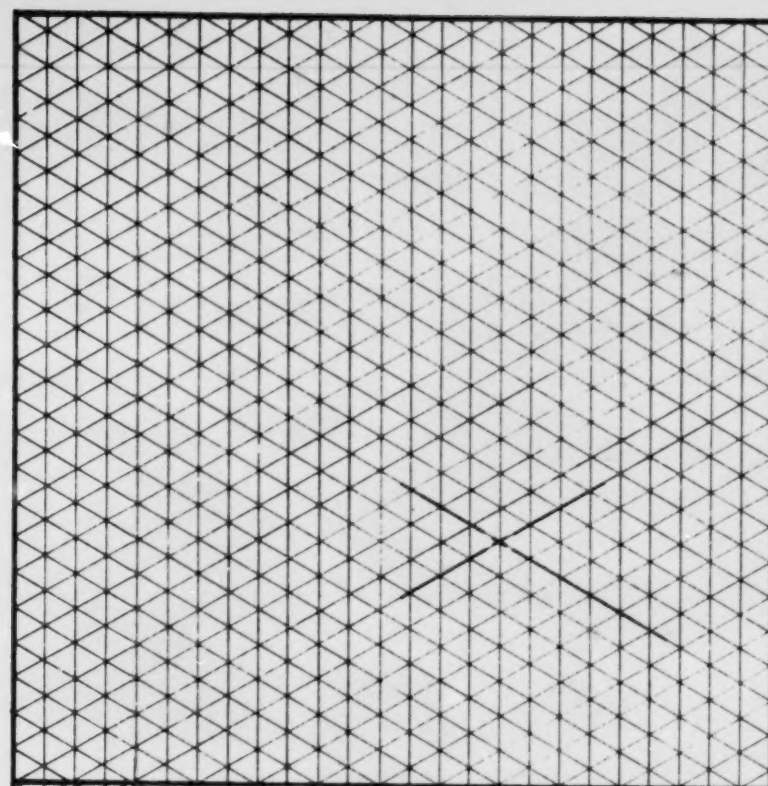
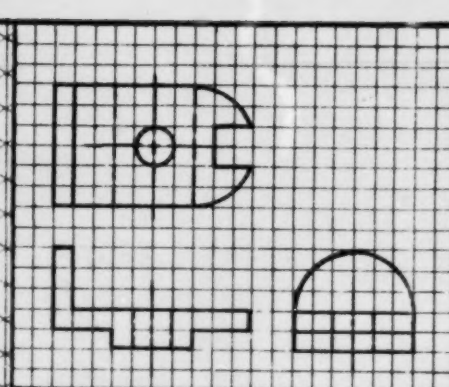
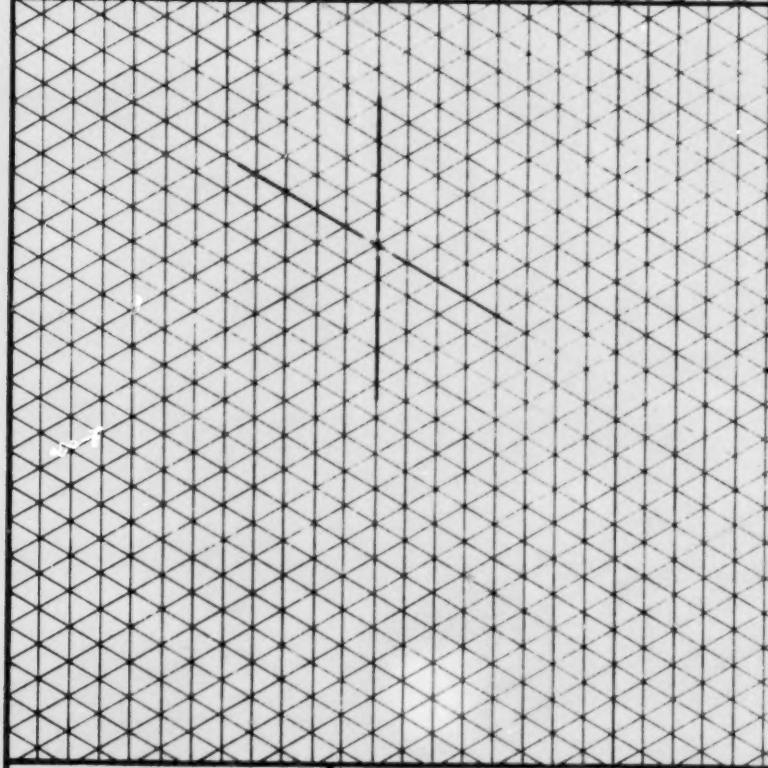
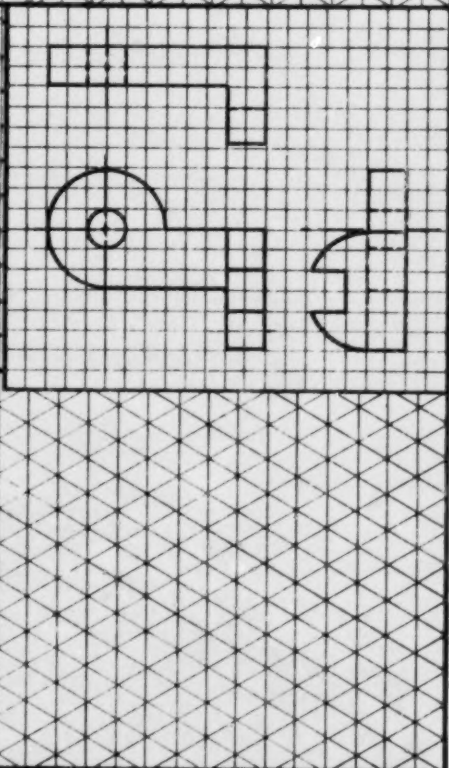
INTRODUCTORY INFORMATION: The term "Pictorial Drawing" refers to just what the term implies, a drawing that is viewed as if it were taken with a camera or as one would normally see an object, in three dimensions. Pictorial drawings are used in sales literature, assembly drawings, technical illustrations, or as a quick and simple way of explaining or conveying an idea to another person, especially a person who is not trained in reading prints.

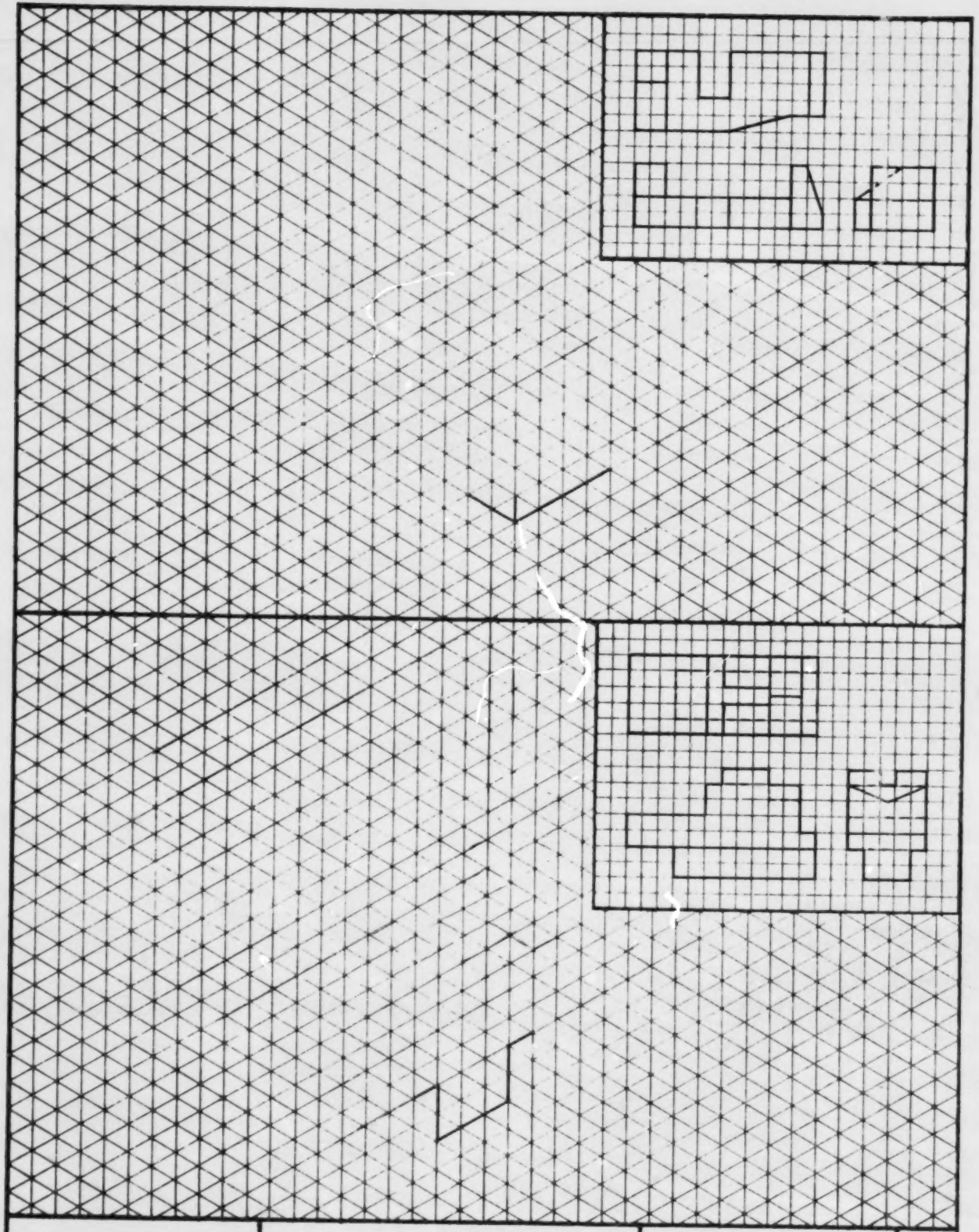
Two types of pictorial presentations most commonly used by machinists are isometric and oblique. Information Sheet II-C-2(IS) explains the difference in each pictorial drawing and how the drawings are made. This assignment will provide the student with an opportunity to develop those skills necessary for the machinist to quickly and accurately sketch an object in pictorial representation.

REFERENCE: Information Sheet II-C-2(IS) "Pictorial Sketches"

**QUESTIONS
OR
PROBLEMS:**

1. In problems 1 and 2, the student will study carefully the orthographic view in the right hand corner and complete the partially drawn isometric view. The student will use the orthographic grid for determining the size of the pictorial view. Show all construction lines and center lines.
2. In Assignment Sheet II-C-2(AS) problems 3 and 4, study the orthographic view in the upper right hand corner and complete the oblique sketch as required. In each problem a reference center is given to assist in the location of the view. For proportion to size, count the number of spaces in the orthographic view and count the spaces off on the oblique drawing. The size ratio is 1: 1: 1, and the receding angle is 45°. Leave construction lines and show center lines.

			
			
NAME:	ISOMETRIC SKETCHES	DATE:	1

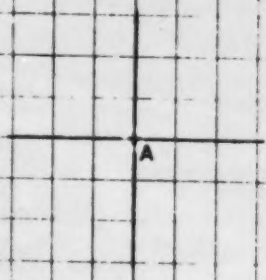
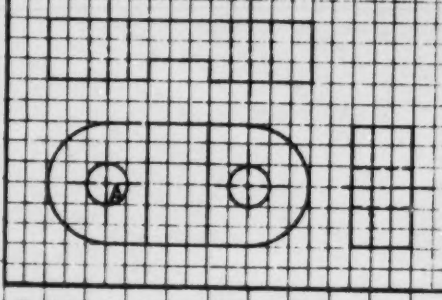
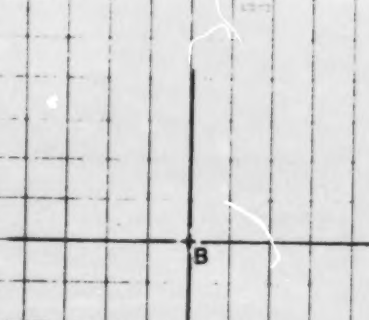
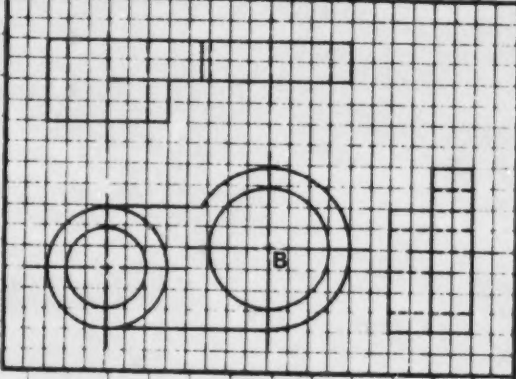


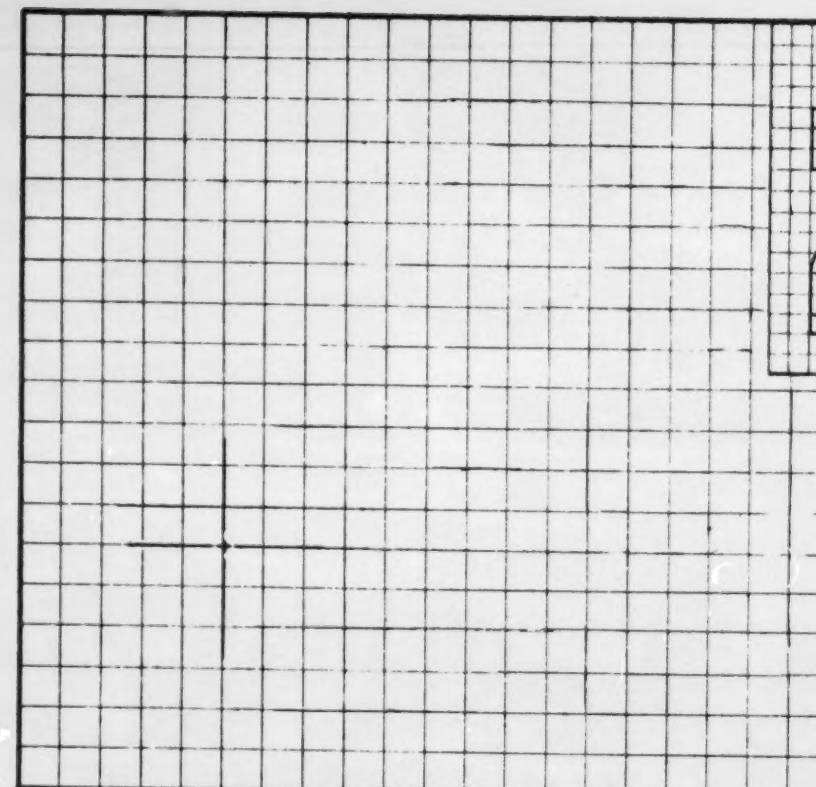
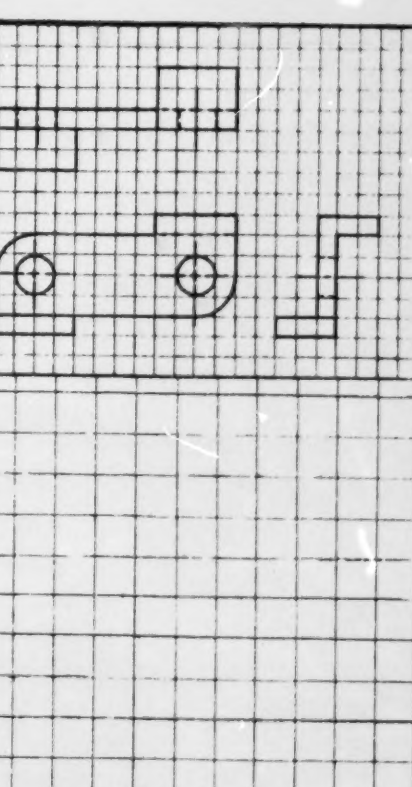
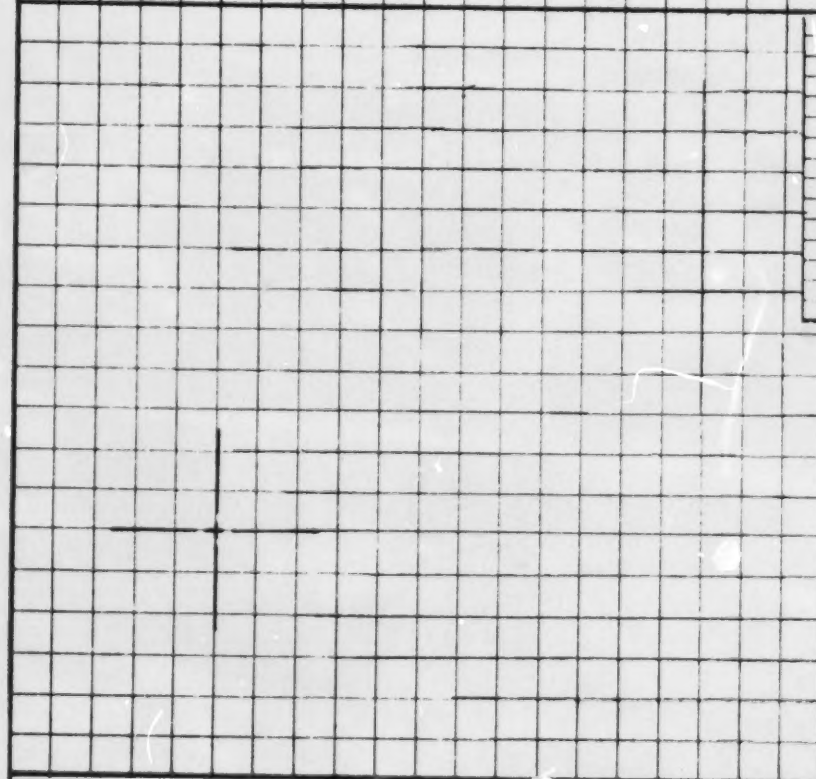
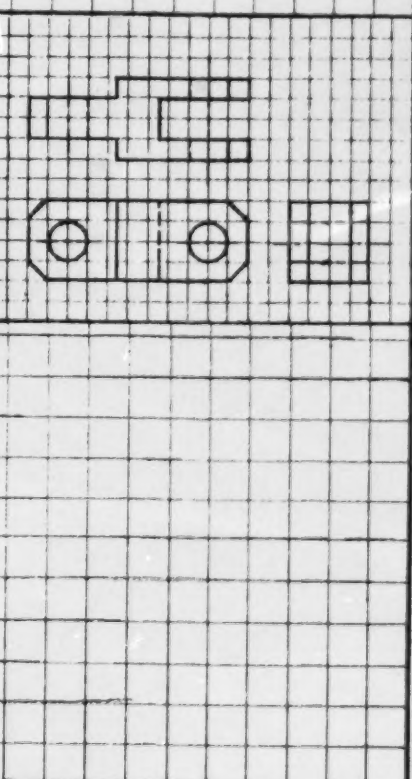
NAME:

ISOMETRIC SKETCHES

DATE:

2

 Isometric coordinate system with origin A. The vertical axis is labeled '1' at the top and the horizontal axis is labeled '1' at the right.	 Isometric drawing of a rectangular block with two circular holes. The holes are labeled A and B.		
 Isometric coordinate system with origin B. The vertical axis is labeled '1' at the top and the horizontal axis is labeled '1' at the right.	 Isometric drawing of a rectangular block with two circular holes. The holes are labeled A and B.		
NAME:	OBLIQUE SKETCHING	DATE:	3

			
			
NAME:	OBLIQUE SKETCHING	DATE:	4

II-C-2(T)
p. 1 of 2

DATE _____

EXAMPLE: 1. Only two axes of a ____ drawing are foreshortened equally. dimetric

- 173

12. Edges that are not parallel to the isometric axis are called ____ lines.
13. A drawing in which the depth axis is reduced to any scale in order to achieve proper proportion is the ____ oblique.
14. Sales illustrations are one of the common uses of a ____ drawing.
15. The depth axis of ____ oblique drawing is drawn to full scale.
16. Lines parallel to the isometric axis are called ____ lines.
17. In an oblique drawing two of the axes are at a ____ angle to each other.
18. Two common perspective drawings are single point (parallel) and ____.
19. Isometric paper differs from cross-section (coordinate) paper in that it has two sets of lines that are drawn at ____ degree angles.
20. Inclined lines of oblique drawings are drawn by locating their ____ points along the parallel axis and connecting the points.

INFORMATION SHEET
ON
PRINT READING

II-D-I(IS)

SUBJECT: Bolt Hole Patterns

INTRODUCTORY
INFORMATION:

Accuracy and efficiency in print reading depend on one's ability to read and interpret conventional methods of conveying graphic information. One of the most important of these methods concerns machining operations such as, drilling, reaming, countersinking, boring, counterboring, and tapping holes.

GENERAL INFORMATION

In dimensioning holes, the diameter of the hole, the depth, operation and the number of holes of that size to be machined are indicated by a note on the print, as covered in Information Sheet II-B-3a(IS), "Abbreviations, Notes, and Symbols". Holes are located with reference to their center lines from a finished surface as a datum plane, as in Figure 1, or from an important center or center line as illustrated in Figure 2.

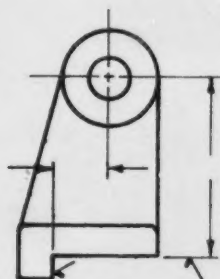


Figure 1

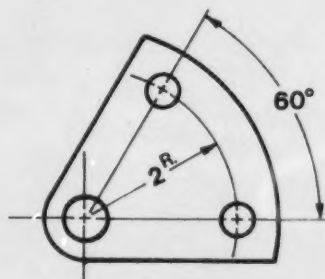


Figure 2

Holes equally spaced about a common center may be dimensioned by giving the diameter (diagonally) of the circle of centers, or as referred to, bolt circle, and are specified "equally spaced" on a note. See Figure 3.

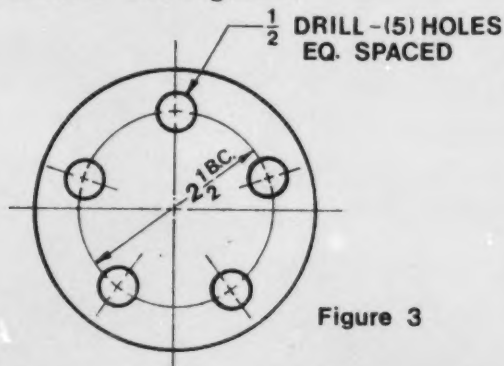
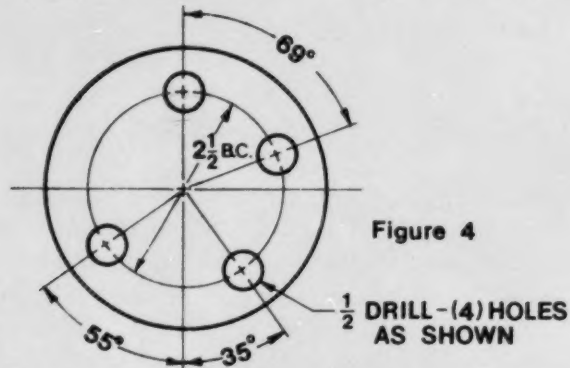
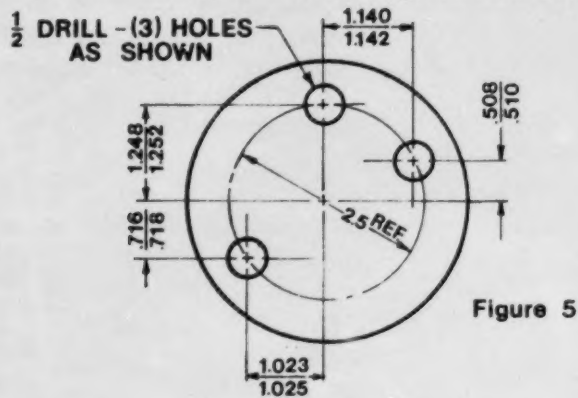


Figure 3

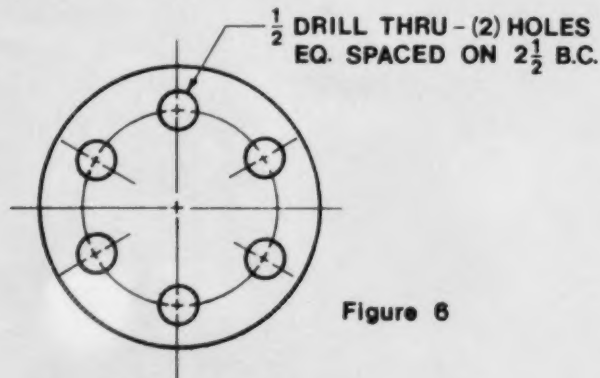
Holes unequally spaced are located by means of the bolt circle diameter and angular measurements referenced to only one of the center lines, as shown in Figure 4.



Where greater accuracy is required, coordinate dimensions are given as in Figure 5. The bolt circle is marked REF to indicate that it is to be used only as a reference dimension. The location dimensions are given in decimals with a tolerance.



Frequently a note is used to give information concerning the hole size, number, location, and bolt circle diameter, as in figure 6.



ASSIGNMENT SHEET
ON
BOLT HOLE PATTERNS

II-D-1(AS)

NAME _____

DATE _____

DIRECTIONS:

Study the drawing that corresponds to this assignment number. Fill in the blank with the information that will complete each statement correctly.

EXAMPLE:

1. The size rounds of the flange are _____. 1/16 R

1. The number of holes to be drilled are _____. _____
2. The maximum limit of each hole is _____. _____
3. The thread relief size is _____. _____
4. The 3 - 1/2" diameter is called the _____. _____
5. Each hole is to be reamed and _____. _____
6. The flange diameter is _____. _____
7. The hole in the lower right quadrant is located _____ from the vertical center axis. _____
8. The thread calls for a class _____ fit. _____
9. The major diameter of the thread is _____. _____
10. The minimum size of the bored hole is _____. _____
11. The counter bore depth is _____. _____
12. The maximum distance from the flange face to the thread shoulder is _____. _____
13. The limits of the counter bored holes are _____. _____
14. The hole in the lower left quadrant is located _____ from the horizontal center axis. _____
15. The symbol on the thread shoulder and back of flange indicates that both are _____ surface. _____
16. The dimensioning technique used for locating the holes is called _____. _____
17. The letter "A" in the thread note refers to a/an _____ thread. _____

18. The hole in the upper right quadrant is located _____
from the hole located on the verticle center axis.
19. The maximum distance between the hole in the lower
right quadrant and the lower left quadrant is _____.
20. The minimum dimension between the center of the
hole on the vertical center axis and the horizontal
center axis is _____.



INFORMATION SHEET

II-D-2(IS)

ON

PRINT READING

SUBJECT: Gears

INTRODUCTORY INFORMATION:

Gears are used to transmit motion, rotating or reciprocating, from one machine part to another by successively engaging the teeth of the gears. They are used in place of belt drives and other types of frictional drives when the exact speed ratio of power transmission must be maintained. Gears may be used to change the speed of a driven shaft, thus increasing or decreasing the torque of the driven member.

A basic knowledge of gears is essential to the machinist because of the universal use of gears in industry and the existence of standard practices for the representation of gears on prints.

The method by which gears are represented on a print is based on the following factors:

1. The type of gear and its features
2. The different parts of gears and their names
3. The formulas used for computing the dimensions of the parts of the gear

GENERAL INFORMATION

Principles of Gearing

The basis of all gearing consists of the imparting of rotary motion by one part to another. Motion can be imparted from one shaft to another parallel shaft by friction, as in Figure 1, or by belt, as on a belt driven drill press. This type of drive is subject to slipping and excessive pressure, and therefore is less effective. This ineffectiveness can be overcome by the use of teeth on one cylinder interlocking with teeth on the second cylinder, as in Figure 2. The interlocking teeth provide a "grabbing" feature by which one gear can drive another gear effectively without loss of power transmission or speed ratio. This mechanical operation is known as gearing. This principle of imparting rotary motion from one part to another by means of interlocking teeth is basic for all methods of gearing, regardless of type of gear.

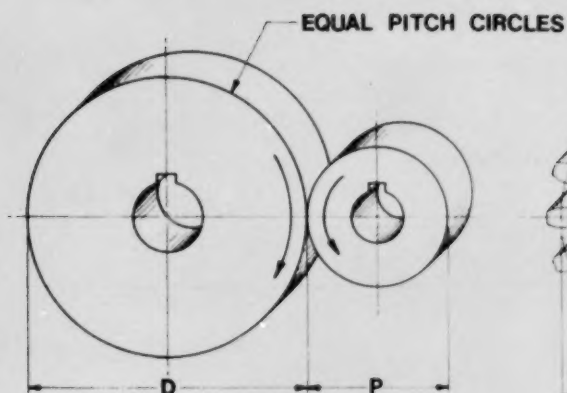


Figure 1
(Friction Drive)

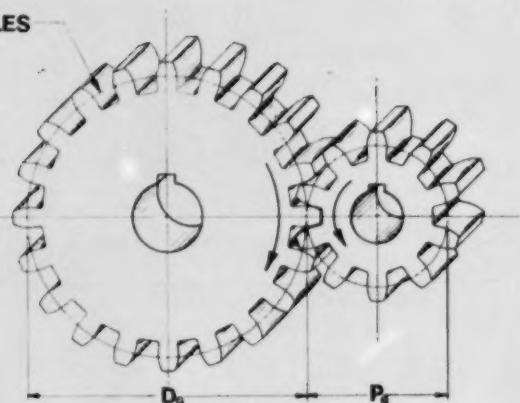


Figure 2
(Gear Drive)

Types of Gears

Gears may be classified according to the position of the shafts they connect. Parallel shafts, for example, may be connected by spur gears, helical gears, or herringbone gears, as in Figure 3.

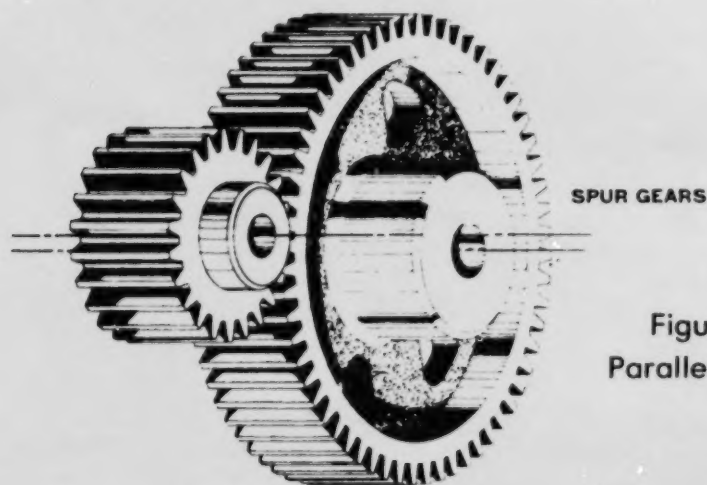


Figure 3
Parallel Shafts

Intersecting shafts may be connected by bevel gears having either straight, skew, or spiral teeth. See Figure 4.

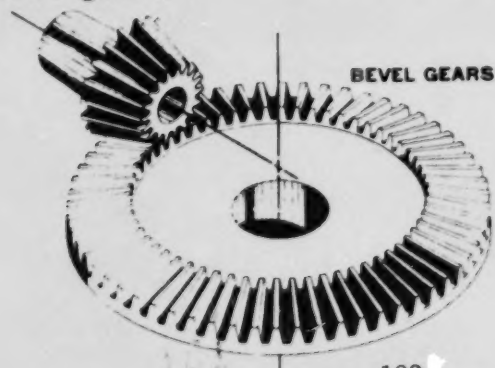


Figure 4
Intersecting Shafts

Non-parallel, non-intersecting shafts may be connected by hypoid gears, used in automobile drives, or a worm and worm gear. See Figure 5.

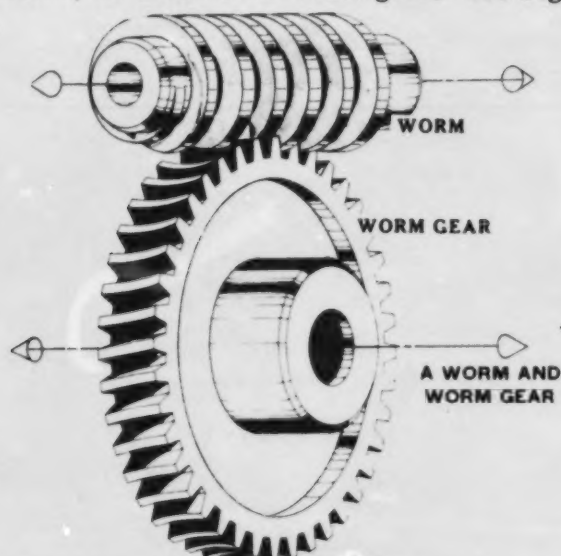


Figure 5

C. Non-Parallel, Non-Intersecting Shafts

A spur gear meshed with a rack will convert rotary to a reciprocating motion, as in Figure 6. This system is common to the lathe, surface grinder, and milling machine.

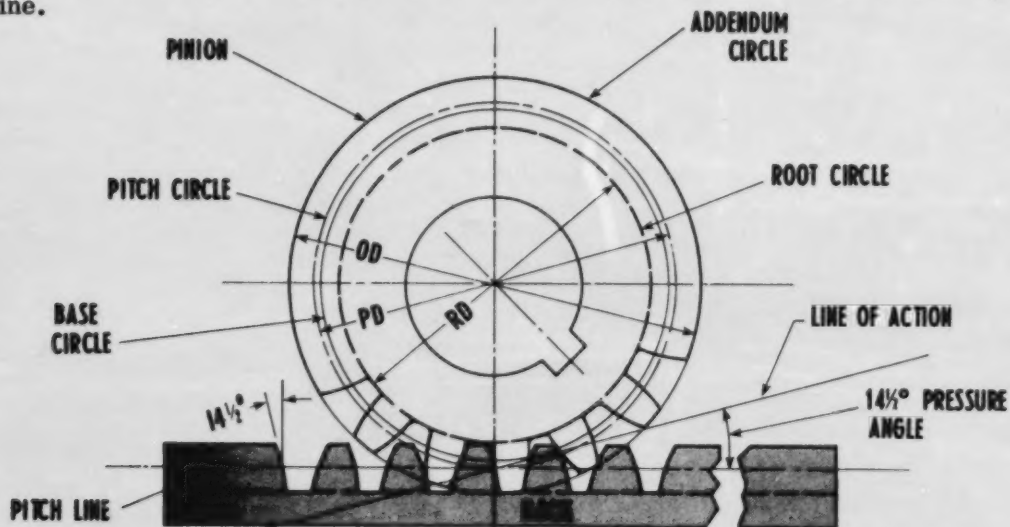


Figure 6

RACK AND PINION WITH $14\frac{1}{2}^\circ$ COMPOSITE SPUR TEETH

Because the design of gears is a complex problem, only the straight-tooth spur gear will be discussed.

Parts of the Gear

When two gears are meshed, as illustrated in Figure 7, the imaginary circle formed by the points of contact between the gears is called the pitch circle. The pitch circle is located about halfway between the top and bottom of the gear teeth.

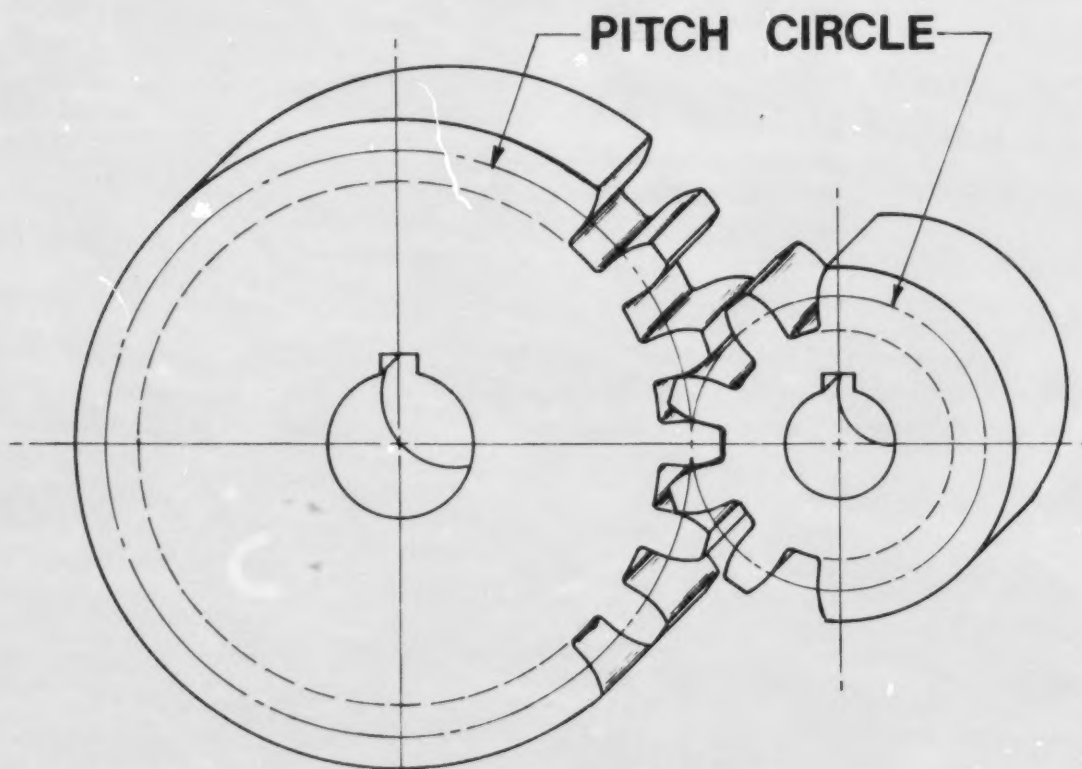
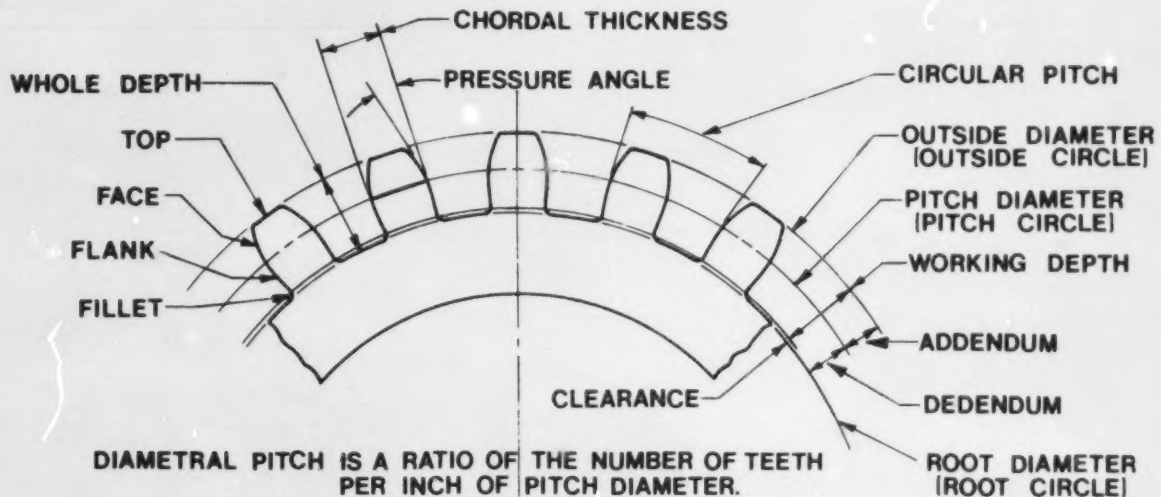


Figure 7
SPUR GEARS

The pitch circle is only one of many important parts of the gear, as illustrated in Figure 8. It is important that the machinist know the terms and definitions of gearing as a part of technical communication, as well as the math formulas used in making calculations for cutting gears.



GEAR NOMENCLATURE

Figure 8

Gear Terminology

Proportions and shapes of gear teeth are well standardized. The terms defined below and illustrated in Figure 8 are common to all gears.

Addendum (A) - The height of the tooth above the pitch circle.

Chordal Thickness (CT) - The thickness of the tooth measured at the pitch circle. Dimension obtained when a gear-tooth caliper is used to measure the thickness at the pitch circle.

Circular Pitch (CP) - The distance from a point on one tooth to a corresponding point on the next tooth measured on the pitch circle.

Clearance (C) - The distance between the top of a tooth from a mating gear to the bottom of the tooth space of a gear being mated.

Dedendum (D) - The radial distance from the pitch circle to the bottom of the tooth space. The dedendum is equal to the addendum plus the clearance.

Diametral Pitch (DP) - The number of teeth in a gear to each inch of pitch diameter. Example: A gear of 10 diametral pitch and a 3" pitch diameter would have 10×3 , or 30 teeth.

diameter. Example: A gear of 10 diametral pitch and a 3" pitch diameter would have 10×3 , or 30 teeth.

Outside Diameter (OD) - The overall diameter of the gear blank.

Pitch Circle (PC) - The imaginary circle of a gear which could be moved by friction alone if it were a simple cylinder. The imaginary circle located approximately halfway between the tops and roots of the teeth.

Pitch Diameter (PD) - The diameter of the pitch circle.

Pressure Angle - The angle between the line of action and the line tangent to the pitch circle.

Rack - A gear with teeth spaced along a straight line and suitable for straightline motion.

Ratio of Gearing - Ratio of the numbers of teeth on mating gears. For example: If the ratio is "2 to 1", this usually means the smaller gear makes two revolutions to one revolution of the larger mating gear.

Root Circle - The circle formed by the bottom of the tooth spaces.

Root Diameter - The diameter of the root circle.

Whole Depth (WD₂) - The total depth of a tooth space, equal to addendum plus dedendum or working depth plus clearance.

Working Depth (WD₁) - The depth of engagement of two gears or the sum of their addendums.

Formulas for Computing Spur Gear Dimensions

There are rules and mathematical formulas used for calculating the dimensions of any part of a spur gear. The basic data always indicated on gear drawings are the number of teeth and the diametral pitch. From these specifications, any dimension can be found by substituting the appropriate values in the formula. The following table contains the basic formulas used to calculate principal characteristics of spur gears.

FORMULAS FOR CALCULATING GEAR DIMENSIONS	
FORMULAS TO FIND:	EXAMPLES:
OUTSIDE DIAMETER = $\frac{\text{NO. OF TEETH} + 2}{\text{DIAMETRAL PITCH}}$ [OD]	$\frac{20T + 2}{10 \text{ DP}} = 2.200$
PITCH DIAMETER = $\frac{\text{NO. OF TEETH}}{\text{DIAMETRAL PITCH}}$ [PD]	$\frac{20T}{10 \text{ DP}} = 2.000$
WORKING DEPTH = $\frac{2}{\text{DIAMETRAL PITCH}}$ [WD ₁]	$\frac{2}{10 \text{ DP}} = .200$
WHOLE DEPTH = $\frac{2.157}{\text{DIAMETRAL PITCH}}$ [WD ₂]	$\frac{2.157}{10 \text{ DP}} = .257$
ROOT CIRCLE DIAMETER = OD - 2 WD ₂	2.200 - 2(.257) = 1.7686
CLEARANCE = $\frac{.157}{\text{DIAMETRAL PITCH}}$ [C]	$\frac{.157}{10 \text{ DP}} = .0157$
CIRCULAR PITCH = $\frac{3.1416}{\text{DIAMETRAL PITCH}}$ [CP]	$\frac{3.1416}{10 \text{ DP}} = .314$
NUMBER OF TEETH = $\frac{\text{OD} \times \text{DP} - 2}{2}$ [T]	$\frac{2.200 \times 10 - 2}{2} = 20$
ADDENDUM = $\frac{1}{\text{DIAMETRAL PITCH}}$ [A]	$\frac{1}{10 \text{ DP}} = .100$
CHORDAL THICKNESS = $\frac{\text{CIRCULAR PITCH}}{2}$ [CT]	$\frac{.314}{2} = .157$

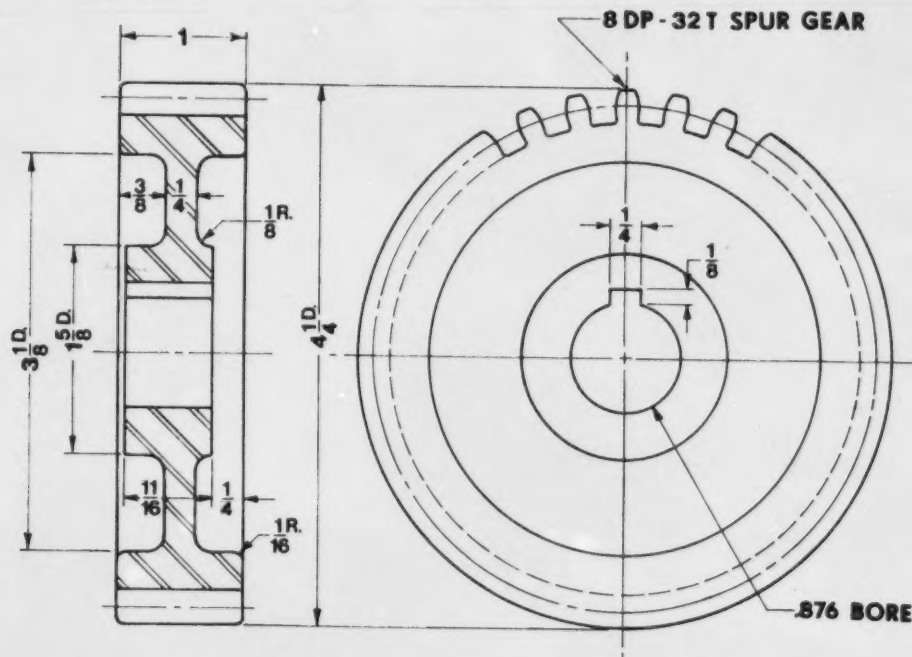
ASSIGNMENT SHEET
ON
GEARS

II-D-2(AS)

NAME _____

DATE _____

Directions: Study the print given and fill in each blank with the correct answer. Refer to the formulas given in Information Sheet II-D-2(IS) for computing the answer.



1. Pitch diameter of gear
2. Diametral pitch
3. Outside diameter
4. Circular pitch
5. Number of teeth
6. Whole depth
7. Diameter of hub
8. Keyway size
9. Addendum
10. Gear face size
11. Bore diameter
12. Length of hub
13. Working depth of tooth
14. Chordal thickness (tooth)

ON
PRINT READING

SUBJECT: Assembly Drawings

INTRODUCTORY
INFORMATION:

Machinist work is not limited to reading and interpreting work drawings only. Frequently it is necessary to refer to drawings that do not deal with such information as what size to machine a part, but the relationship of a part with other component parts when they are assembled together. In addition, the machinist may be called upon to install a machine, assist in planning the setup of machine tools in the plant, or in the overall maintenance and repair of equipment. These situations require the ability to read special drawings referred to as "assembly drawings".

GENERAL INFORMATION:

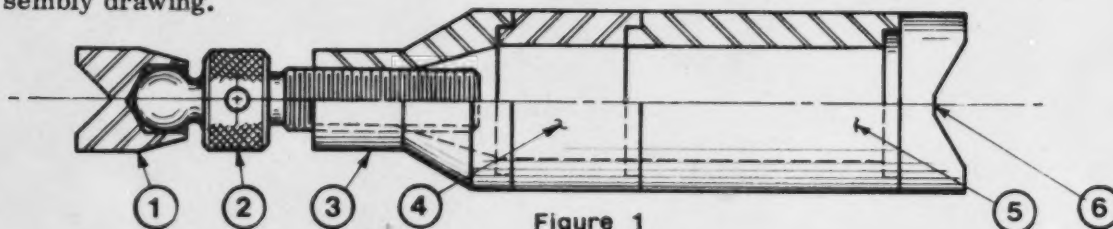
Purpose

The main purpose of an assembly drawing is to provide information concerning the relationship of individual parts of a machine, structure or multipart tool or object. They may be drawings that show how individual parts assemble together; the overall appearance of the part as a whole; provide installation dimensions and directions for maintenance and operation. Also assembly drawings are used in the advertising of a tool or machine.

Types

Assembly drawings will vary according to their use. They may be drawn either as a pictorial or orthographic representation. The following are types of orthographic assembly drawings:

General Assembly drawings serve primarily to show how individual parts of a machine or multipart object fit together. All of the parts are drawn in their functional position. This type drawing is useful in the assembly phase of machines. Each individual part is identified by either a number or reference letter enclosed in a circle with a leader line pointing to the part, (A), (2), and is used in conjunction with details and a bill of materials. Figure 1 illustrates an example of a general assembly drawing.



Work Drawing Assembly drawings are used for parts or objects that are not very complicated. The drawing gives complete information for producing the total assembled part by providing the necessary views required, including dimensions, notes, and symbols as required to produce the part, and the assembly of all parts. Each part is referenced by letter or number, as discussed previously, to the parts list or bill of materials, as shown in Figure 2.

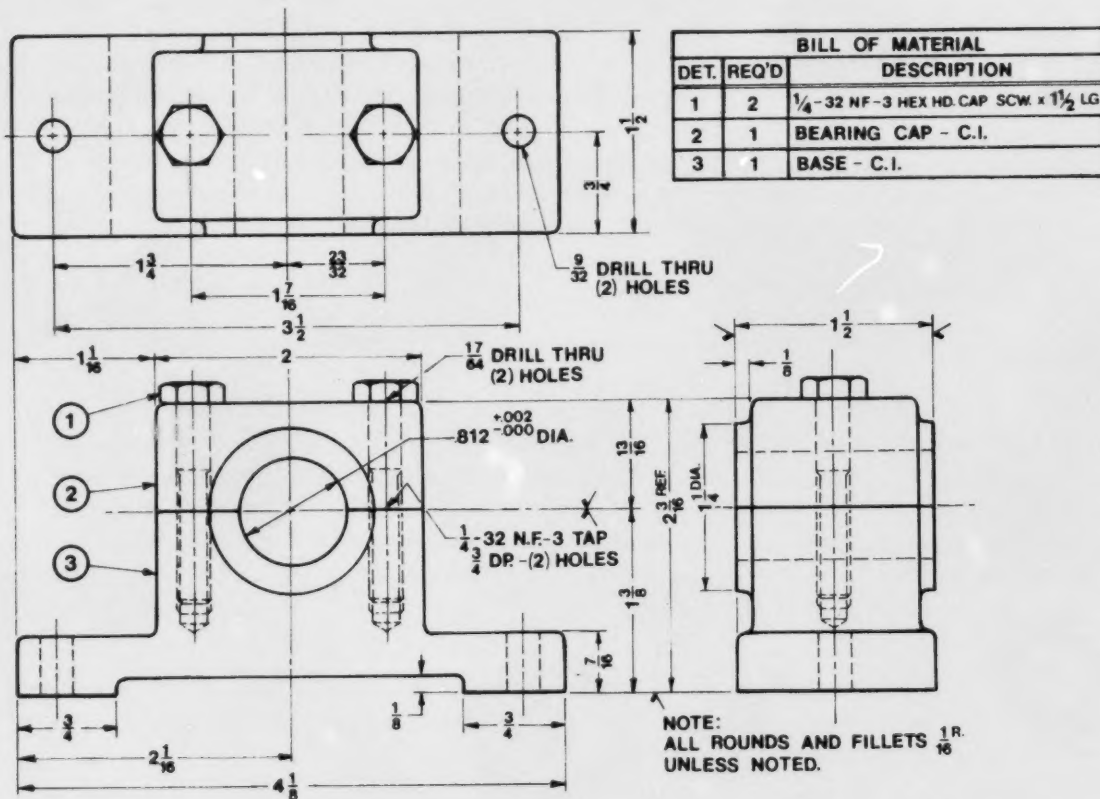


Figure 2

Installation Assemblies are made specifically to show how a machine or structure is installed or erected. This type of drawing is referred to as an outline assembly, because only the outlines and relationships of exterior surfaces are shown. See Figure 3.

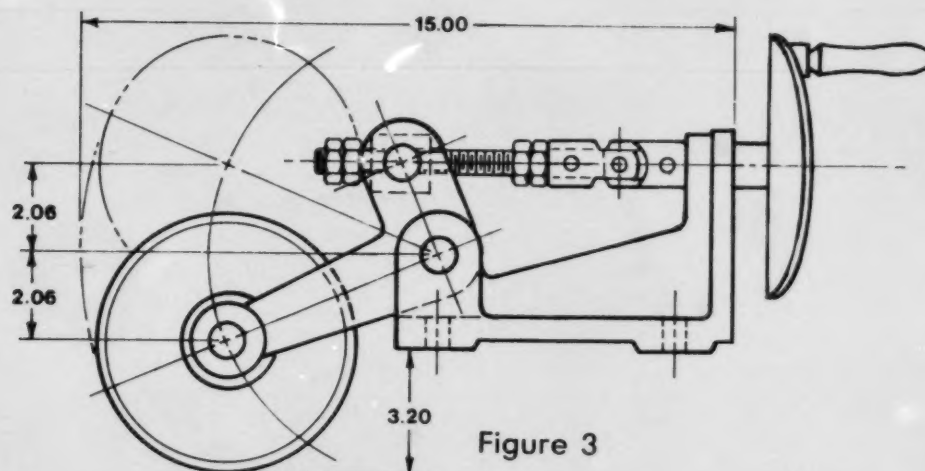
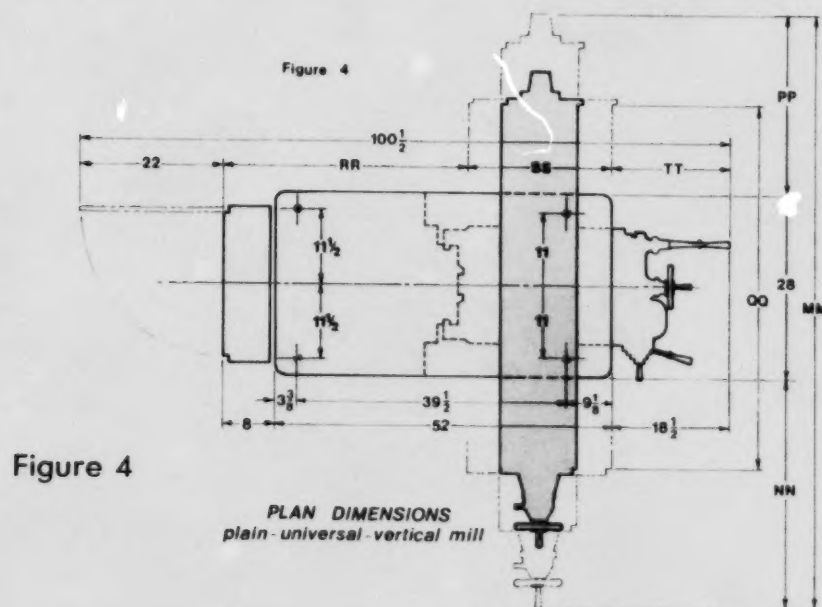


Figure 3

Dimensions given on the print are normally given to indicate the amount of spaces needed to install it properly. Frequently, a machine will have a large number of dimensions, and placing the dimensions on the drawing becomes complex. In such cases, the dimensions are substituted by letters or numbers that refer to the actual dimensions located in the reference table, as in Figure 4.



Machine	MM	NH	PP	OO	RR	SS	TT
205 S-12	101	40	33	56	38 1/4	22	18 1/4
207 S-12	114	46 1/2	39 1/2	62 1/2	38 1/4	24	16 1/4

Pictorial Assembly drawings may be classified into two common types. One is the cutaway drawing as shown in Figure 5.

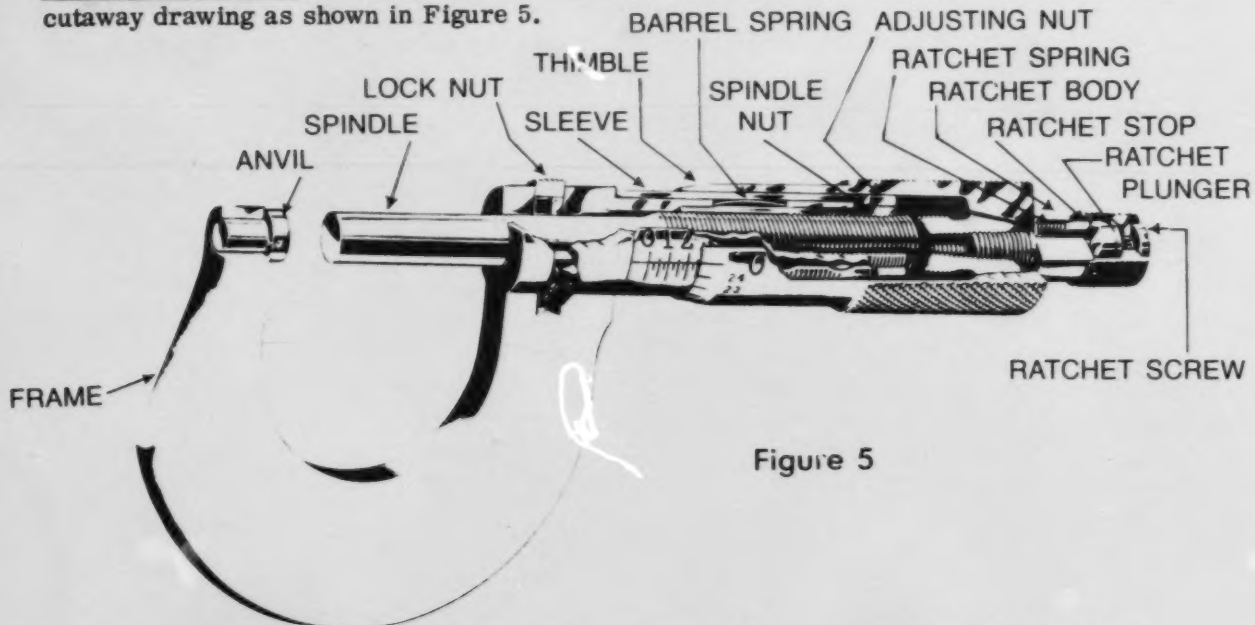


Figure 5

The part is drawn as a sectional view in order to show the interior details. The drawing is shaded much like a photograph and is commonly referred to as a production illustration. It is used primarily in sales materials and catalogs.

A second means of presenting a pictorial assembly is by use of an exploded drawing, as in Figure 6. Each part is drawn pictorially with the location and order of assembly shown. Each part is identified by name or a number which is referenced to a parts listing. This type of drawing is used in repair manuals for ordering repair parts, and frequently accompanies a machine to assist in assembly and identifying parts.

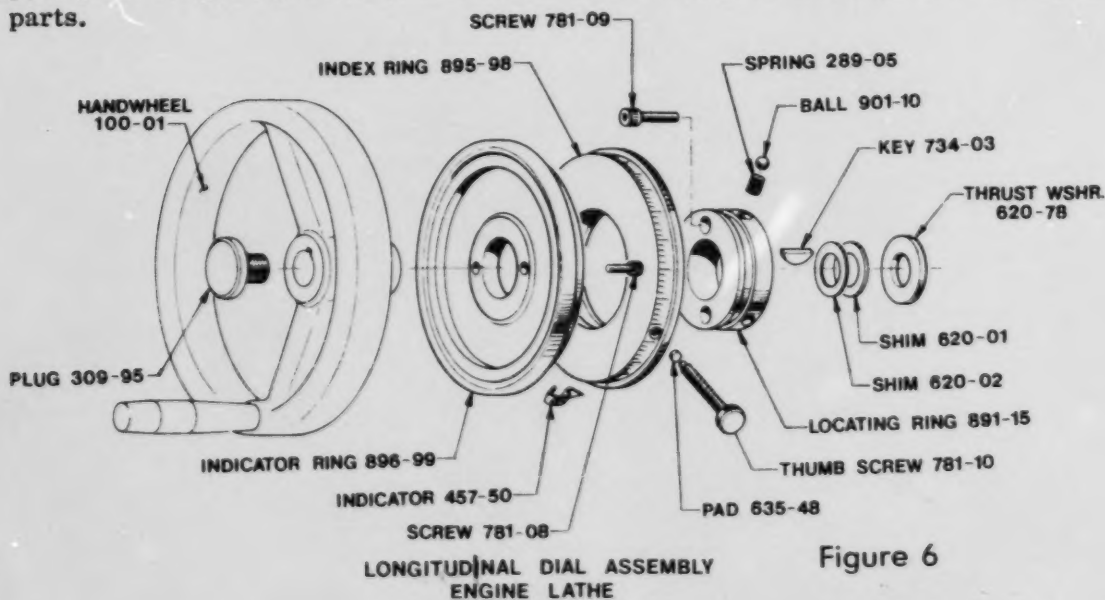


Figure 6

ASSIGNMENT SHEET
ON
ASSEMBLY DRAWINGS

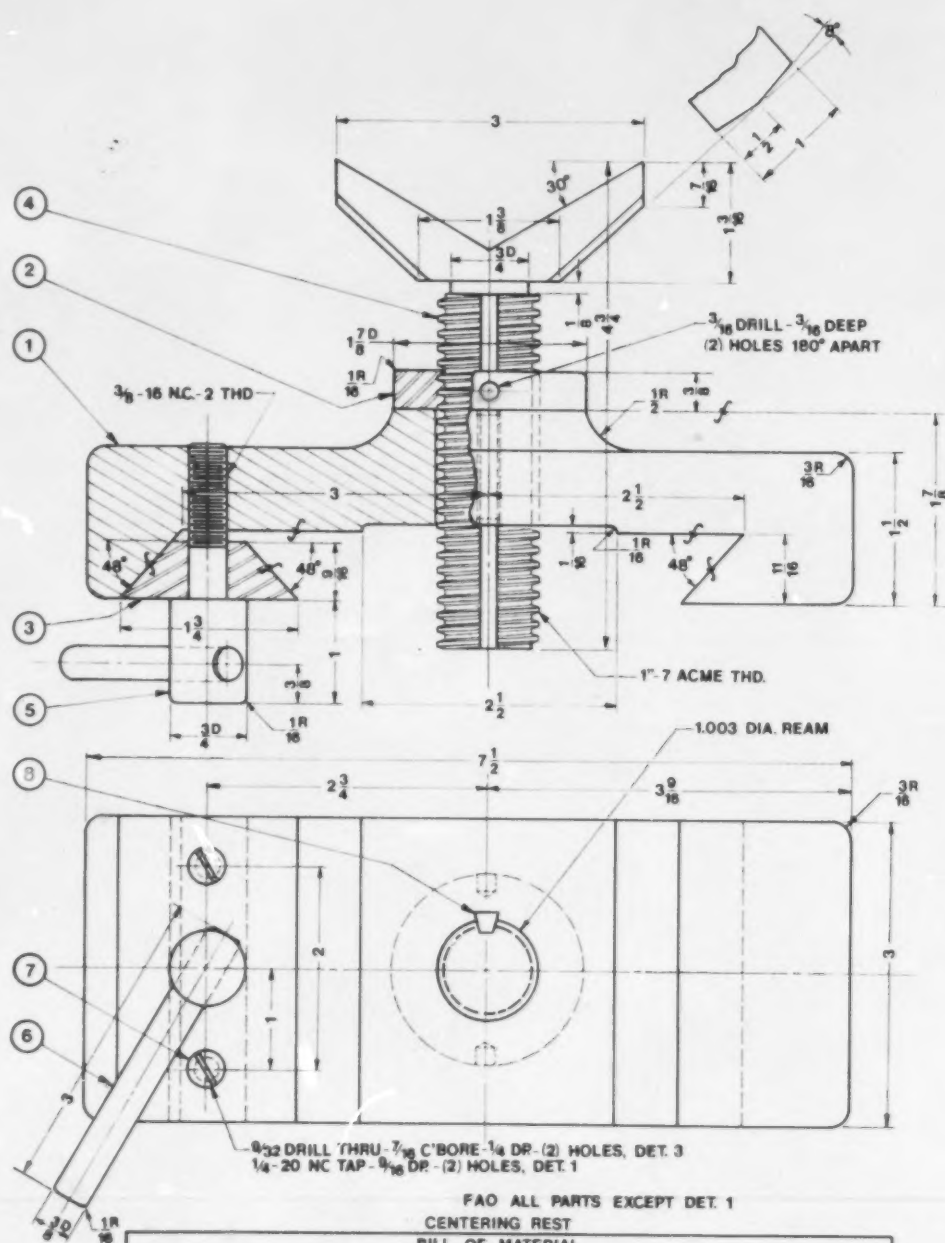
II-D-3(AS)

NAME _____

DATE _____

Directions: Read the drawing that corresponds to this assignment number. Write the correct information in the blank space to complete each statement.

1. The O.D. of the adjusting nut is _____. _____
2. The included angle of the V-block of the rest is _____. _____
3. The overall size of the clamp is _____. _____
4. The clamp handle is made of _____. _____
5. There are three fillet sizes in detail #1, 1/16", 3/16", and _____. _____
6. The depth of (2) 3/16" diameter holes is _____. _____
7. The depth of the dovetail in the base is _____. _____
8. The total length of detail #2 is _____. _____
9. The distance between the filler head screws is _____. _____
10. The internal angles of the dovetail are _____. _____
11. The length of the reamed hole is _____. _____
12. The length of the ACME thread is _____. _____
13. The base height of the centering rest is _____. _____
14. The locating dimension for the dovetail in the base is _____. _____
15. The thread machined on the clamp screw is _____. _____
16. The diameter of the center hole in the base is _____. _____
17. The ACME thread relief is _____ in diameter. _____
18. The maximum overall assembled length of this fixture is _____. _____
19. The base has _____ tapped holes. _____
20. The minimum sized material required to make detail #2 is _____. _____



DET. REQ'D	DESCRIPTION	DET. REQ'D	DESCRIPTION
1 1	BASE - C.I.	5 1	CLAMP SCREW - SAE 1020
2 1	REST - SAE 1020	6 1	CLAMP HANDLE - SAE 1020
3 1	CLAMP - SAE 1020	7 2	1/4-20 x 1" LG. FIL. HD. CAP SCR.
4 1	ADJUSTING NUT - SAE 1020	8 1	KEY - SAE 1040

GLOSSARY

Abrasive: Crushed sharp crystals of grinding material used in the form of grinding wheels, polishing cloth, and lapping powder.

Acme thread: A thread system used extensively for feed mechanisms. It is between a square thread and V-thread. The thread angle is 29° .

Acute angle: An angle less than 90° .

Align: To set mechanisms or machines in proper relation to each other.

Allowance: An intentional difference in dimensions between mating parts.

Alphabet of Lines: The type and weight of lines used in drafting.

Angle: The geometrical figure formed by two intersecting straight lines; also, the space between the intersecting straight lines.

Anneal: To heat a metal piece to its critical temperature and then allow it to cool slowly, thus reducing brittleness and increasing ductility.

Assembly: The finished separate pieces put together according to the assembly drawing.

Base Circle: In the designing of gears, it is the circle on which the involute tooth is constructed.

Boring: A machine operation consisting of enlarging a hole to specified dimension with a boring tool.

Boss: A projection, usually cylindrical, on a casting or forging.

Broach: To finish the inside of a hole to a shape usually other than round with a long cutting tool which has a series of teeth that gradually increase in size.

Brown & Sharpe Taper: A taper system used in milling machine spindles and machine tools. Sizes are numbered and all have a taper of $\frac{1}{2}$ inch per foot except the No. 10 which is .5161 inches per foot.

Burnish: To polish to a smooth finish by working a smooth tool against moving or revolving surfaces.

Bushing: A metal sleeve or bearing upon which a pulley or wheel turns; a liner for a hole to make it smaller.

Carburize: To heat a low-carbon steel to approximately 2000^o F for several hours in a box packed with carbonizing material, then allowing to cool slowly in preparation for heat treatment.

Caseharden: To harden the outer surface of carburized steel by heating to critical temperature and then quenching in oil or water.

Chamfer: The flat surface formed by cutting off a sharp corner, usually having an angle of 45^o.

Chase: To cut threads in a lathe, as distinguished from cutting threads with a die.

Chatter: Noise produced by the rapid vibration of a machine tool against the work being machined.

Core: (1) That part of a mold which shapes the interior of a hollow casting. (2) The unaffected interior of a case hardened piece.

Counterbore: To enlarge an end of a hole cylindrically with a counterbore.

Countersink: To enlarge an end of a hole conically with a countersink.

Cutting Plane: An imaginary plane used to cut through an object to produce a sectional view.

Die: (1) One of a pair of hardened metal blocks or plates used to cut or form a required shape. (2) A tool for cutting external threads.

Die-casting: A method of producing castings to finished size by forcing molten metal into a suitable mold; an object or part formed by die-casting.

Dowel: A pin or other form of metal projection, anchored in one piece and fitting into a hole in an abutting piece to prevent motion or slipping, or to keep the pieces in their correct relative position.

Draft: The angle given a molding pattern to permit it to be withdrawn from the mold without disturbing the mold form.

Draw: (1) To stretch or shape metal by hammering. (2) To temper steel by gradual or intermittent quenching.

Drill: (1) To cut a cylindrical hole with a drill, usually a twist drill. (2) A pointed cutting tool rotated under pressure.

Drop forging: A shaped object formed between dies by the use of a drop hammer; the process of forging with a drop hammer.

Eccentric: Deviating from the center or from the line of a circle.

Elongated hole: A hole which is not completely circular by reason of the inserting of a flat area. Dimensioned by giving the radii of the two halves plus the dimension of the flat area.

Face: To machine a flat surface on a metal piece by means of a machine tool.

Fillet: A concave surface or filling at the intersection of two surfaces to provide increased strength.

Fin: A thin projecting edge on a casting or other metal surface.

Fit: The type and closeness of contact between two surfaces.

Forge: To shape hot metal by hammering or pressing a piece of metal which has been formed while hot.

Graduate: To mark in regular degrees of measurement, as in a scale or dial.

Grinding: A machine operation which consists of finishing a metal surface by means of abrasives.

Half Section: View in which cutting plane passes only half way through an object and one quarter is removed.

Horizontal: Parallel to horizon.

Hub: The central part of a wheel such as the part into which the spokes are inserted.

Jarno Taper: System of dimensioning tapers by diameter and length. The taper is .6 inch per foot in all sizes.

Jig: A fixture for locating, holding the work, and guiding the cutting tool in opera-

tions such as drilling, reaming, counterboring, and countersinking.

Kerf: The slit or groove produced in a piece of stock by a saw or cutting tool.

Key: A bar, pin, or wedge used to secure an object to a shaft to prevent relative movement between the two pieces.

Key Seat: The groove which holds the key in position, as in a shaft. To form a seat for a key by cutting.

Knurl: To roughen or indent a turned surface, such as a knob or a handle, to produce a better hand grip.

Lap: A soft metal surface impregnated with fine abrasive for use in polishing operations.

Lug: A projecting piece through which something is attached, bears on, or passes.

Major Axis: The long diameter of an ellipse.

Major Diameter: The largest diameter of a screw thread.

Mill: To shape or dress metal by means of a rotary cutter on a milling machine.

Minor Axis: The shorter diameter of an ellipse.

Morse Taper: A system of standard dimensions for tapers, the taper being approximately 5/8 inch per foot. Used most commonly on taper shank drills.

Normalizing: Heat treatment of steel to improve grain and structure, performed by heating it above its critical temperature and then cooling in air.

Perpendicular: Lines or planes at a right angle to a given line or plane.

Picture Plane: An imaginary plane between the object and observer.

Piercing Point: The point at which a line or projecting element pierces a projection plane.

Pinion: The smaller of two mating gears.

Pitch: The distance from a point on one screw thread to a point on an adjacent thread taken along a straight line parallel to the axis of the thread.

Pitch Diameter: Diameter of an imaginary circle that would pass through a screw thread at such points as to make width of thread and width of space equal at point where they are cut by circle.

Principal View: The view of an object which shows the most detail and contour of the object. Example: Front view.

Profile: To machine an outline by moving a small rotating cutter usually controlled by a master cam or die.

Ream: A machine operation consisting of enlarging a hole slightly with a rotating fluted tool to provide greater accuracy.

Relief: A slight variance in the dimension of a machine part to allow for clearance.

Shear: To cut material by placing the material between two blades and exerting force on the blades in opposite directions.

Shim: A thin piece of metal placed between two parts to adjust the fit between the parts.

Slippage: Loss of motion in the transmission of power.

Spline: A projection on a shaft or hub which fits into a slot or groove of another part.

Spot face: To machine a round spot on a rough surface, usually around a hole to give a good seat to a nut or bolt.

Square: A four-sided figure having four equal sides and four right angles.

Straight Angle: An angle of 180° .

Supplementary Angles: Two angles whose sum is 180° .

Surface roughness: Roughness refers to the finely spaced irregularities produced in fabricating a part. The height of the irregularities is rated in microinches.

Tangent: A line drawn to the surface of an arc or circle so that it contacts the arc in only one point.

Tap: A machine tool for forming internal screw threads; to cut internal threads with the use of such a tool.

Taper: A uniform change in size.

Temper: To heat-treat hardened steel to make it harder by reheating it to below its critical temperature and allowing it to cool.

Template (or templet): A thin plate used as a guide for the form and shape of the piece to be made; also a gage for checking the form and shape of a piece.

Tolerance: Permissible variation in the size of a machined part, usually specified as a maximum, or upper limit, and a minimum, or lower limit.

Torque: Twisting force set up in or by a revolving shaft.

Triangle: A closed geometric figure having three sides and three angles:

1. Equilateral triangle: three sides and angles are equal.
2. Right triangle: one angle of the triangle is 90° .
3. Isosceles triangle: two sides are equal.

Turn: To shape a part by applying the cutting tool to the work while the work revolves on a shaft or spindle.

Waviness Height: Waviness refers to surface irregularities spaced too far apart to constitute roughness. Both height and width of waviness irregularities are rated in inches.

